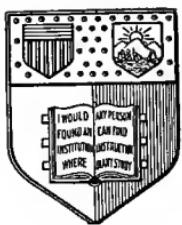


AGRICULTURE

ITS FUNDAMENTAL PRINCIPLES

BY
SOULE
AND
TURPIN

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WOODS IN SPRING
Dogwood in Blossom

AGRICULTURE

ITS FUNDAMENTAL PRINCIPLES

BY

ANDREW M. SOULE

PRESIDENT OF GEORGIA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

AND

EDNA HENRY LEE TURPIN

“At the head of all the sciences and arts, at the head of civilization and progress, stands — not militarism, the science that kills, not commerce, the art that accumulates wealth — but agriculture, the mother of all industry, and the maintainer of human life.” — GARFIELD

B. F. JOHNSON PUBLISHING COMPANY

ATLANTA RICHMOND DALLAS

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PREFACE

A FEW years ago the study of agriculture was introduced into common schools as an experiment; now, in most states it is on the list of required studies — a place to which its importance well entitles it. The subject is as interesting and as teachable as it is important, dealing in a practical way with the elementary principles of many sciences.

The purpose of teaching agriculture is not to make a farmer of each child, any more than the purpose of teaching literature is to make an author of each one. The study is, however, especially useful to children who will some day be men and women with good farms to maintain or poor ones to improve. The knowledge of the forces and laws which control plant and animal development raises the daily round of farm tasks from drudgery to intelligent labor. As labor is better informed, it is better directed; it brings larger returns in dollars and in happiness.

The aim of this book is so to state the scientific facts and principles which underlie the processes of agriculture that they will be intelligible and interesting to young people. These principles are stated briefly but clearly; illustrations and examples are drawn from common crops and methods. The constant effort is to bring the student in contact with nature, to have him observe for himself how plants live and develop under various conditions, to learn by these observations and by simple experiments the relation of the soil and its elements to crop growing, and to understand how the processes of nature may be influenced and aided by man. By means of the experiments described and suggested, every student can use to advantage the great laboratory of nature.

It is believed that the full experiments and exercises on every topic, the orderly arrangement of subjects, the clear chapter outlines, and the full index make this book especially valuable for class-room use. The appendix supplies useful tables and suggestions for supplementary study of special subjects. No pains has been spared to make the illustrations really illustrate the text, and thus add to the value as well as to the attractiveness of the book.

The authors and publishers desire to make acknowledgment to the Department of Agriculture, Washington, D.C., for the use of numerous illustrations belonging to it. For photographs, information, and other assistance, thanks are due to Professor W. B. Alwood, Miss S. B. Sipe, to many persons connected with the Department of Agriculture, and to the directors of various State Agricultural Experiment Stations,

SUGGESTIONS TO TEACHERS

1. Discuss with pupils the topic assigned for study in the text-book, so as to excite their interest.
2. Collect beforehand materials needed for experiments to illustrate each topic.
3. Ask pupils to perform experiments and bring specimens to illustrate the subject under discussion.
4. Encourage pupils to observe good and bad methods of farming; make with them excursions to observe special crops and methods.
5. Have a school garden and make use of it for experiment and illustration. Each child should work in the garden, and if possible each one should have a plot for the care of which he is responsible.
6. Write to your State Agricultural Experiment Station for information and bulletins, and to the Department of Agriculture for bulletins and seeds.
7. In addition to the text-book, each pupil should have a notebook, in which he keeps a neat pen-and-ink record of experiments, of work in school garden, and of supplementary work and reading.
8. Each pupil should have also a drawing book, a hard pencil, a soft pencil, and an eraser. He should illustrate each topic as fully as possible with copies from pictures and with drawings from objects. This exercise teaches habits of careful and accurate observation.
9. For work in the garden, each child needs a light hoe and a ten- or twelve-tooth rake, and a string with which to lay off straight rows.
10. In performing experiments to illustrate the text, the teacher will find the following articles useful: an alcohol lamp, three straight lamp chimneys, three small glass tubes of different sizes, a set of iron soil sieves, two grain sieves, a dozen six-inch flower pots with saucers, three thermometers, an eight-ounce graduated glass, blue litmus paper, a dozen heavy glass tumblers, a dozen large-mouth bottles, seeds and cuttings of common plants, a collection of crop plants and weeds and insects, and the few chemicals mentioned in the text. If these articles are unavailable, the teacher need not be disengaged. Common seeds and plants, some bottles, wooden and pasteboard boxes, and old tin cans furnish material for interesting experiments.

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OUTLINE OF CHAPTER ONE

THE SOIL

Uses of Soil:

Root-hold and home for plant

Storehouse for water, air, heat, and plant food

Soil Makers:

Heat and cold

Atmosphere

Water:

Vapor, rain, dew, frost, snow, and ice

Living forms:

Bacteria, fungi, mosses, higher plants

Earthworms, ants, higher animals

Classes of Soil:

Sedentary, or in place

Transported, or carried:

By wind

By water

Alluvial, by streams; drift, by glaciers

Farm Soils:

Sandy

Clay

Loam

Limestone

Soil Moisture:

Uses of water:

Supplies plant food

Dissolves and carries plant food

Sources of loss:

Percolation, or passing through soil spaces

Evaporation, or changing from a liquid state to a vapor

Transpiration, or giving out, as vapor, from leaves

Lack supplied by irrigation

Excess removed by drainage

Soil Ventilation:

Uses of air:

Supplies oxygen to plant roots

Supplies carbon dioxide for chemical processes

Evils of under-ventilation

Evils of over-ventilation

Soil Temperature:

Warmth needed for:

Germination of plants

Growth of plants

Chemical processes and work of bacteria

Soil warmth affected by:

Slope of land

Nature of soil

Moisture

Soil warmed by:

Drainage

Tillage

Manures

Composition of Soil:

Some metallic elements:

Iron, calcium, magnesium, potassium, sodium, aluminium

Some non-metallic elements:

Silicon, sulphur, phosphorus, chlorine, carbon, oxygen, hydrogen, nitrogen

AGRICULTURE

CHAPTER ONE

THE SOIL

FORMATION OF THE SOIL

Soil. — We are now to consider the processes by which Nature brings forth harvests from the soil, and the ways in which man can aid and direct her work.

What, in the first place, is the soil?

It is the thin layer of surface earth which covers our globe. It is composed of fine particles of rock, mixed with matter formed by the decay of plants and animals. Its thickness is measured by feet, often by inches. Below it for many miles extends the solid earth-crust.

Probably you are familiar with some place where a river or road has cut its way through a hill. There you can examine the layers of the earth-crust. On the top you find grass or weeds or trees. Below that is the soil, which is generally dark in color; gradually this changes into the subsoil, which is harder and usually lighter colored. Under that there is a layer of rock.

Importance and Uses of Soil. — Compared with the size of the earth, the soil is no more than a film of dust on an orange. Yet it is this film, this surface-layer, this earth-dust, which gives us the fragrant beauty of the rose, the grateful shade of the oak, the wholesome food of the corn. Without it, plant and animal life could not

exist. It supplies a root-hold and home for plants. It is a storehouse for the water, air, and heat which they need. It is a manufactory, too, in which forces and organisms are at work changing matter into forms that plants can use for food.

Formation of Earth-crust. — Have you ever considered how the soil was formed? We are told that long ago the earth was a fiery mass of matter whirling through space. Gradually it cooled, and as it cooled it hardened into a sphere, or round body. Its surface was a crust of solid rock, surrounded by heavy acid vapors.

Bare and lifeless as a ball of iron, it whirled through space. There was no foothold for the tiniest plant, no home for the humblest insect. Then God set His servants, the forces of nature, to work to make the barren rock an abode for plants and animals. Many agencies worked, singly and together.

Heat and Cold. — First, there were heat and cold. As you know, heat causes most substances to expand, or grow larger, and cold makes them contract, or grow smaller. As the earth-surface cooled, the rock contracted, cracked, and broke, forming elevations and depressions, or hills and valleys. The cold condensed the heavy acid vapors surrounding the earth and they descended in rain. Continents rose, small at first, but increasing in size as the earth-crust shrank and cracked. The waters flowed in streams through narrow valleys and in deep ones formed lakes, seas, and oceans.

Atmosphere. — The atmosphere, or air and gases and vapors around the earth, worked slowly but constantly. It crumbled the earth-surface and bore the rock-dust from one place to another.

Water. — The greatest part of the soil-making, however, was done by water in its various forms — vapor, rain, dew, frost, snow, and ice. As a gas, a liquid, and a solid, it worked and is still working. During those early days water was busy, — rain and streams



Permission of Forestry Service

WATER AT WORK

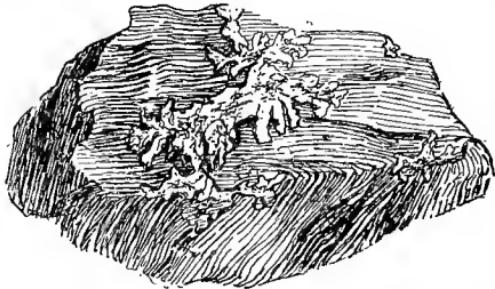
The Rapids of the Catawba River in North Carolina.

wearing down the rocks, ice breaking them, frost crumbling them, making the particles fine and ever finer.

Fungi, Lichens, and Mosses. — Even before the rocks were ground and crumbled, there arose simple forms of vegetable life,

fūn'gi, lī'chens, and mosses.

They drew some food from the air, and dissolved and absorbed other food from the rock. Their decay added to the rock-dust the material gathered from the air. This formed soil. It was poor and shallow at first, able to nourish only



LICHENS ON A ROCK

fungi, mosses, and other simple forms of life.

But countless generations of low forms of plants and animals deepened and enriched the soil. Higher and yet higher forms succeeded. Untiringly, unrestingly, worked the forces of nature, so slowly that at the end of a year or a century little advance was visible, but so surely that the earth became a fair garden spot, rich in vegetable and animal life.

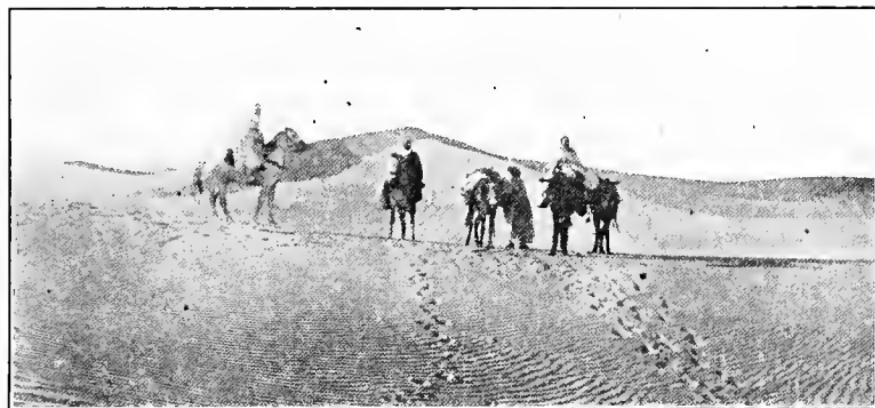
Classes of Soils. — According to their origin, soils are divided into two classes, sēd'en ta rŷ and trans pōrt'ed.

Sedentary Soils. — Sedentary soils, or soils in place, are those that rest upon the rock from which they were formed. The soil differs from the rock in being fine, loose, and porous, so as to admit air, water, and roots. It is crumbled rock, subjected to the action of plant and animal organisms and mixed with matter formed by their decay.

Transported Soils. — But all soils do not rest upon the rocks from which they were formed. Many have been transported, or

carried, and deposited hundreds of miles from the parent rock. The two chief soil-transporters are wind and water.

Wind as Soil-transporter.—Probably you have seen snow whirled along and heaped up by a gust of wind. In the same way the winds gather up soil and bear it along wherever it is loose and unprotected by vegetation. In the Desert of Sahara there



SAND HILLS IN THE DESERT OF SAHARA

are sand drifts larger and deeper than snowdrifts ever are in New England. Wind shifts sand on the seashore and along the lakes, but it is not an important soil-transporter in many parts of our country.

Water as Soil-transporter.—The world's great soil-transporter is water. The rain is constantly carrying soil from hills to valleys. Streams are constantly bearing it along and depositing it on their banks. Have you noticed a brook after a sudden summer shower? The water, usually as clear as crystal, is dark with mud; it rushes along, bearing particles of soil and even gravel and stones.

Suppose you take a glassful of this muddy water and let it stand a few hours. The water will be clear again, but at the

bottom of the glass will be a sediment of mud. This is soil which the rain washed down into the brook. The amount in one

glass of water is small, but think how much the brook and all the other streams transport. Where a rolling field is undrained and badly tilled, every rain steals some of its fertility; later you will learn how a farmer can protect his land against such thefts.

On the left is a glass of muddy water; on the right is the same a few hours later, showing sediment.

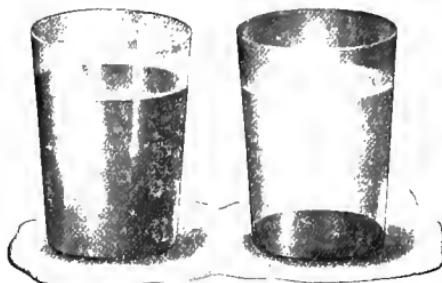
Alluvial Soils.—Streams bear

down to the ocean a vast amount of soil, but far less than they get from the hillsides. Like greedy children, they take more than they want and have to leave part. They drop it in shallows and leave it along the banks. This material, deposited by water, forms *alluvial* soils. They are usually fertile loams, rich in organic matter.

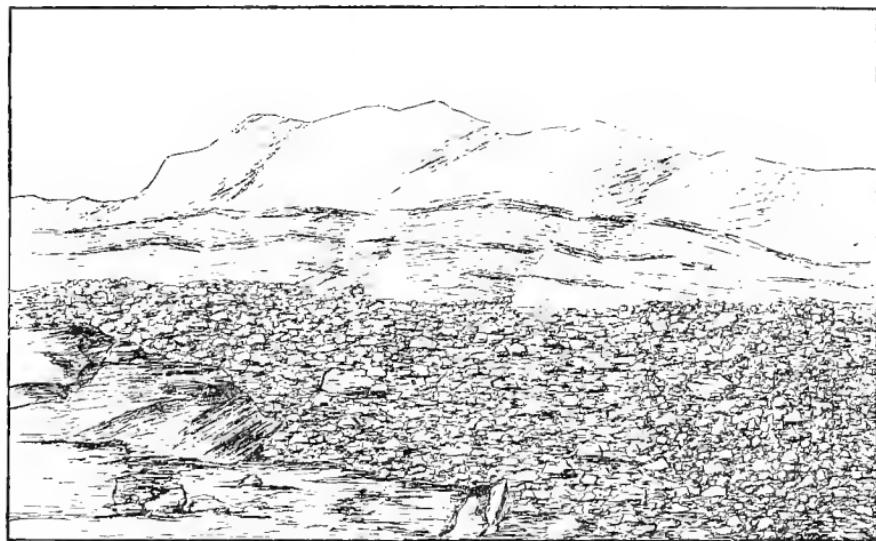
Egypt, 'the gift of the Nile,' is formed of soil brought from distant mountains by heavy rainfalls and floods. So Louisiana is the gift of the Mississippi. The sediment which forms its fertile soil has been brought hundreds of miles by the river. Each year the Mississippi carries to the ocean enough soil to cover two hundred and sixty-eight square miles with a layer one foot deep.

Drift Soils.—Most of the soil of America in the great area north of the thirty-ninth parallel is a transported soil. It was formed, not by streams of water, but by *glaciers*, or streams of ice.

The Glacial Period.—Thousands of years ago, the climate in the region north of the equator became very cold. There came a long, long winter which destroyed plant and animal life. Snow fell until it was hundreds and thousands of feet deep. This formed a glacier,



a mass of ice many hundreds of feet thick. It extended from the Arctic regions southward to central Pennsylvania and from New England to the Rocky Mountains, covering two thirds of North America. The glacier moved far more slowly than does water, but its grinding and transporting power was much greater. It wore down hills and filled up valleys. Like a giant millstone, it ground rocks to powder. At last it melted, depositing a layer of soil.



A GREENLAND GLACIER

The ice-mass is darkened by soil and rock waste. The rounded pebbles and rocks have been transported hundreds of miles and deposited by the melting glacier.

Soils of the United States. — The underlying surface rock of the northern part of the United States is chiefly sandstone; had the soil been formed from this, it would have been thin and poor. The soil formed by the glacial deposit is usually deep and fertile, being formed by the grinding and mixing of a variety of rocks.

The soils of New England are nearly all drift or alluvial; those of the Southern states are alluvial or sedentary.

Soil Fertility. — Left to the processes of nature, as a rule, soil becomes more fertile, more productive, year by year. Is this the case when it is cultivated by man? It ought to be. Good farming maintains and increases the fertility of soil. This fertility, or productive power, is well termed ‘the farmer’s capital.’ If his methods are good, he preserves and increases the fertility of his land. He draws a large interest in good crops, and adds to his capital. Thus year by year he and his farm are enriched. If his methods are bad, his crop lessens his capital; every year his farm grows poorer, and so does he.

Methods in America. — There are to-day in the United States thousands of acres of ‘worn out’ land which fifty years ago were cultivated fields and a hundred years ago were forests. On the other hand, there are thousands of acres which industry and skill have reclaimed from barrenness and made productive.

EXPERIMENTS

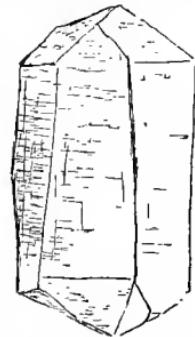
1. Put some clean stones in water. Let the water freeze and then expose it to heat. Repeat several times and then examine it. What causes the sediment at the bottom?
2. Scrape lichens from a stone. Compare it with a freshly broken rock. Notice how the lichen-covered stone is marked and furrowed. Why is this?
3. Stir into a pint of clear water as much clay as it will dissolve. Let it settle, and then measure the sediment. What does this show as to the soil-bearing power of water?

FARM SOILS

Let us examine three substances which we may regard as the basis of soils. These three substances are sand, clay, and humus.

A knowledge of their properties will enable us to understand more clearly the characteristics, or natural traits, of soils.

Sand. — Here is a piece of quartz. If you pulverize, or powder it, you will have sand. But the rock is so hard that you would find this difficult to do; so we will fill a gill measure with sand, which is rock that has been worn down by natural processes. You observe that the sand is heavy, and that it consists of little hard grains. If you try to press it into shape, the dry grains fall apart. Mix it with some water, noticing how much it will absorb, or hold. You can press the wet sand into shape, but it dries quickly and then falls apart again if you handle it. Now put the sand into a glass half full of water, and stir it. The particles separate readily, but when you stop stirring they sink quickly to the bottom of the glass. Soon the water will be clear again. The dry sand does not stick to your fingers, and you can easily rub off the wet particles.



A PIECE OF QUARTZ

Clay. — Now take a piece of potter's clay. It is so much softer than quartz that we can, without difficulty, grind it to powder. Let us fill a gill measure with this powder, and examine and test it as we did the sand. We find that it is light in weight. Instead of feeling hard, it is soft to the touch; that is because the particles composing it are very small. If you squeeze it in your hand, it takes the imprint of your fingers. Mix it with water. You find that it absorbs much more than did the sand, and that you can mold it into any shape you wish. It does not dissolve readily in water, and when it does dissolve, it settles very slowly, leaving the water discolored a long time. You find that the wet clay is sticky, and even the dry clay adheres to your fingers and soils them.

Differences between Sand and Clay. — What have we learned, from these experiments with sand and clay? We have found that sand is heavier in weight than clay; it is composed of small, hard grains which do not adhere closely; it holds little water, settles quickly in water, and is not sticky. We have learned that clay consists of very small particles which adhere closely; it holds



SOIL PARTICLES, MAGNIFIED
162 TIMES

much water, does not settle quickly in water, and is sticky. These differences are largely the result of one thing, a difference in texture. The texture of sand or clay, like that of cloth, depends upon the size of its particles and their relation to one another. We say of clay, as of muslin, that its texture is 'fine' and 'close,' — that is, its particles are small and near together; we say of sand, as of

bagging, that its texture is 'coarse' and 'loose,' — that is, its particles are large and far apart.

Humus. — But let us look at the dark-colored substance called humus, which we place in a third gill measure. Humus is not formed, as are sand and clay, by the breaking down of rocks; it is formed by the decay of vegetable matter. You observe that humus is light in weight, lighter than clay and much lighter than sand. It is soft to the touch, because its particles are very fine. It absorbs a great deal of water and dries very slowly. Its capacity for absorbing and holding water and heat is a very important quality of humus. Although humus is soft to the touch, it is not sticky like clay, and it does not 'bake,' or dry hard.

Effect of Humus on Sand and Clay. — Now let us divide this humus and add half to the sand and half to the clay. We find that

it modifies the qualities of both; it binds together the particles of sand and enables it to hold more moisture; it makes the clay less adhesive or sticky, and keeps it from baking when it dries.

Farm Soils. — Let us see the application to agricultural soils of these facts about sand, clay, and humus. A farmer will tell you that the four chief classes of soils are sandy, clay, loam, and limestone. These are the most important and most widely distributed. Later, you will learn their special adaptations to crop plants and how their qualities may be modified and improved.

Sandy Soil. — A sandy soil is made up largely of sand. Farmers call such a soil 'light,' although it is the heaviest in weight. The term is applied to its working quality. It is light and easy to work, because its particles do not adhere closely. It is so open in texture that air and water pass freely through it; thus it recovers quickly from rain and can be worked early in the spring.

Clay Soil. — A clay soil contains large quantities of clay. It differs from sandy land in the fineness and relations of its particles; though it is lighter in weight than sand, farmers call a clay soil 'heavy' because it is heavy or hard to work. This is due to the fact that its particles adhere closely. Water, air, and heat do not penetrate it readily, but it has great power to absorb and retain moisture. Heavy winter rains make it wet and cold, so that it cannot be worked until late in the spring. If plowed too wet, it runs into a sticky mass and bakes when dry. If plowed too dry, it breaks in hard clods.

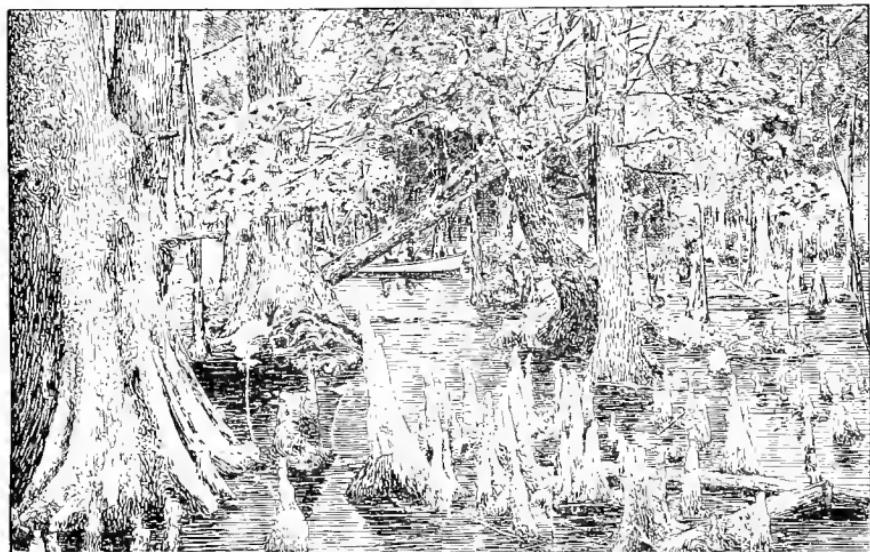
Loam. — Loam is composed of a mixture of sand, clay, and humus. According to the quantity of sand or clay, it is called a 'sandy loam' or a 'clay loam.' Loam is easy to work. Its porous texture enables air and water to penetrate it readily, and its humus enables it to retain water and heat.

Limestone Soil. — A limestone soil is one derived from limestone

rock. Other things being equal, "limestone country is rich country." The soil is generally dry, warm, and healthy for stock; and its luxuriant growth of grass especially fits it for stock raising.

Alkali Lands. — Al'ka li soils contain large deposits of mineral salts which check vegetation. They are found in dry regions in the western part of the United States, in Egypt, in India, and in other countries.

Swamp Soils. — Swamp soils, found in what are or have been lowlands, contain a large amount of decaying vegetable matter.



A SCENE IN THE DISMAL SWAMP

The great Dismal Swamp in Virginia and North Carolina has, by continued deposits of vegetable matter, been raised above the surface of the surrounding country.

EXPERIMENTS

1. Try for yourself the experiments with sand, clay, and humus described on pages 16, 17, and 18.

2. Get specimens of sandy and clay soil and loam. Compare them as to color and weight, and as to size of particles.

3. Make a rack, like the one in the illustration, by boring holes in one side of a box. Get three glass tubes or straight lamp chimneys, tie a cloth over the smaller end of each, and put in one sand, in one clay, and in one garden loam or wood mold. Set them in the rack with the lower end of each over a glass of water, as illustrated. Pour water into them. Through which does it percolate first; which absorbs most water before it begins to drip; which takes longest to become dry?

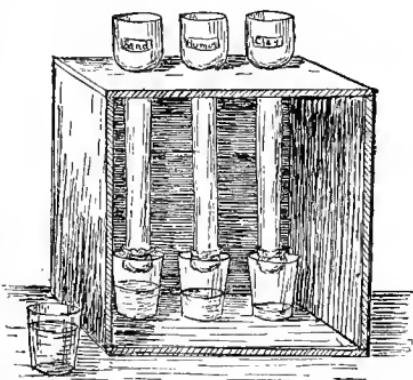


ILLUSTRATION OF EXPERIMENT 3

For this and other experiments it is well to have an eight-ounce graduated glass, such as druggists use, in which to measure water.

4. Fill three tubes, as before, with the three kinds of soil. Set them in the rack with the lower end of each in a glass of water. In which tube does water rise most rapidly, and in which does it rise to the greatest height?

5. What is the character of the soils of your section? Collect and examine some specimens and write an account of them.

Many interesting experiments with soils may be made by the use of a set of soil sieves, which separate particles according to size. Separate a soil and make the same tests with each of the classes. The differences in power to absorb and retain water are due largely to the differences in size of particles.

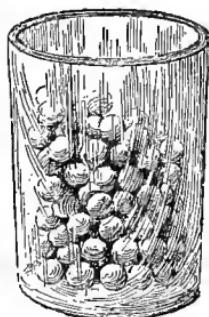
SOIL MOISTURE

Plants' Need of Water.—The soil is the home of plants, the storehouse of their food. We know that it is necessary to the growth of crops, and yet it is not necessary to plant life.

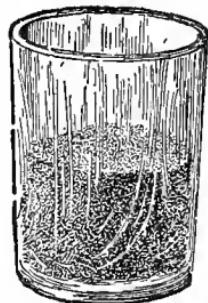
A seed, such as Indian corn, will sprout in water. If there be added to the water certain substances which it needs for food, the plant will continue to grow and flourish without soil.

Uses of Water.—But no plant will grow in any soil without moisture. Moisture is needed to make the seed germinate, or sprout; the plant can take its food from the soil only in a liquid form. Water dissolves plant food, conveys it to the roots, bears it through the stem and branches to the leaves, where it is prepared for food; thence it is carried where it is needed in the structure of the plant.

An enormous quantity of water is required for these purposes. A twenty-five-bushel crop of wheat uses over five hundred tons of water during its season of growth. Where does the wheat get this water? The amount is far in excess of the usual rainfall during



A. In this tube is shown the amount of water required to wet the pebbles in the glass.



B. In this tube is shown the amount of water required to wet the sand made by crushing the pebbles in *A*.

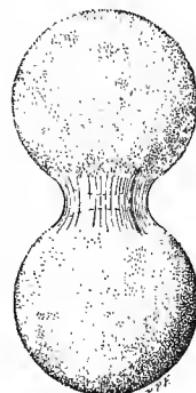
its growing season. Some it gets from the air, but for the greater portion it depends upon its storehouse, the soil.

Soil Water.—If you dig down into the soil, you find it moist below the dry surface, even when there has not been rain for several days. Each particle of this moist soil is surrounded by a film of water. Around these particles is air. The finer the particles of soil, the more numerous are the water films and the air spaces. Fine-grained clay can contain three or four times as much water and air as can coarse-grained sand. Careful experiments prove that under average weather conditions there is in twelve inches of well-tilled loam about four thousand barrels of water to the acre. Near or far below the surface, a depth is reached where the soil spaces are filled with water instead of air. This is called the 'water table.'

The water in the soil is always in motion. Sometimes it is drawn downward by the force of *grav'ity*. Sometimes it is drawn upward by the force of *cap'il lär'i ty*.

Gravity.—Gravity is the tendency of particles or bodies toward a center of attraction. It is this force which makes the apple fall and which makes the rain sink into the wet earth. Coarse, sandy soils offer little resistance to gravity and allow water to sink freely, but fine clay soils hinder its action. If this force worked alone, all water would sink into the earth out of reach of plant roots.

Capillarity.—The force of gravity is counteracted by the force of capillarity, or *căp'il lär'i* attraction. Capillarity causes a fluid to ascend through a porous substance; it makes oil rise in the lamp wick, ink in the blotter,

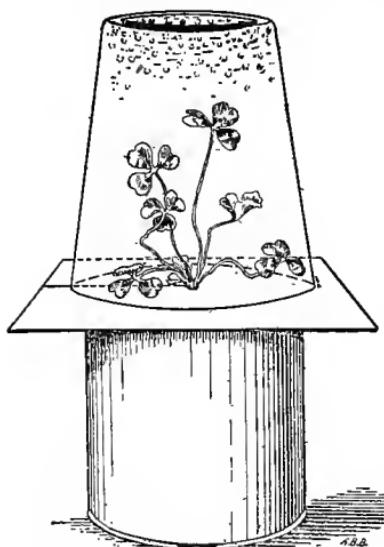


Capillary water held between two soil grains, greatly enlarged.

water in the soil. A coarse, sandy soil has little power to lift water by capillarity, because its particles are so far apart. In a clay soil, on the other hand, the particles are so close together that they hinder capillary movement. Capillarity works best in soils of medium texture.

Soil Loss of Water.—The soil loses water in three ways,—by per co lā'tion, by trans pi rā'tion, and by e vap o rā'tion.

Percolation.—By percolation water passes through the soil, and is carried by the force of gravity out of reach of plant roots. This loss is greatest in coarse, loose soils. They need to be kept compact to hold the water near the surface.



The moisture condensed on the glass was transpired by the plant.

Evaporation.—Evaporation is the passing off of moisture into the air as a vapor. If you spill water on the floor, in a little while it disappears. It evaporates. Much of the moisture brought to the soil surface by capillarity is removed by evaporation. In hot, dry weather, it removes water faster than capillarity can supply it; that is why the surface becomes dry and parched.

Transpiration.—Much of the water taken up by plants is returned to the air by transpiration, or being given out through the pores of their leaves. Transpiration is greatest in hot, dry, windy weather. Plants differ greatly in the amount of water which they transpire. Willows, poplars, and other wet-loving trees are like great pumps, drawing water out of the soil and

pouring it into the air. For this reason they are sometimes planted in wet pastures to dry them so that grass will grow there.

Care of Soil Moisture. — As agricultural plants need much moisture, farmers in most sections find it important to conserve, or save, and utilize soil moisture as fully as possible. The methods used depend largely on soil, climate, and weather conditions. A soil's water-holding capacity is increased by deep plowing, and by the addition of manures and of humus. Loss by evaporation can be checked by stirring the surface so as to form a soil-mülch, or layer of loose soil, an inch or two thick. This separates the particles so that they cannot lift the moisture from the soil and subsoil to the surface, where it is carried off by evaporation.

Irrigation. — In some sections the rainfall is scanty or uneven and the 'water table' is far from the surface. Even when the soil moisture is properly cared for, there is not enough to supply crop needs. This may be the case with soils which are rich in plant food. Are these to be given over to barrenness? It has been found wise and practicable to irrigate these lands,—that is, to supply them with water by a system of reservoirs and canals connected with streams. Lands thus reclaimed are often wonderfully productive. There are millions of acres of land in the western part of the United States which need irrigation.

Drainage. — While some soils are barren for lack of water, others are useless for agricultural purposes on account of its excess. We have already seen that some plants can live without soil in water supplied with plant food. Does it, then, seem contradictory to say that plants can have too much water? In fact, it is not that they have too much water, but that they have too little air. Plants, like animals, need oxygen, and this oxygen they take in chiefly through their roots. Like animals, they are drowned and die if deprived

of air. Some air reaches the roots of plants in water, but it is excluded from close, saturated soils.

You may have seen stunted, sickly-looking stalks of corn in a marshy place, while near by on better-drained land were large, thrifty plants. In wet land, the roots' supply of air is so limited that growth is stunted. Certain plants, such as rice, are adapted to saturated soils, as fish are to water. But most agricultural plants need well-drained soil. There are millions of acres of land in the United States which need drainage to make them productive.

EXPERIMENTS

1. Fill a glass with gravel or small pebbles and pour into it as much water as is needed to wet them,—that is, to form water films around each one without leaving any free, or standing, water. Crush the pebbles as fine as you can so as to form a coarse sand, and see how much water is required to wet this.

Which requires more water, the pebbles or the sand, and why?

2. Put a layer of gravel in a pan and then fill it with water. Put in this three glass tubes of different sizes, supported in a rack or frame. Notice that the smaller the tube is, the higher the water rises. Thus water rises higher through small soil spaces than through large ones.

3. Repeat experiments 3

and 4 described on page 21. What force causes water to descend in the soil? What force causes it to rise?

4. Put a plant with long roots in a bottle nearly full of water. Put paper around the stem and cover it with paraffin so as to make the bottle air-tight. Measure the height of the water and weigh the whole. Meas-

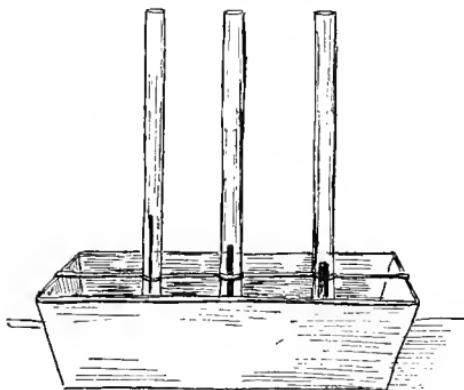


ILLUSTRATION OF EXPERIMENT 2

ure and weigh it again in one week, and in two weeks. What has become of the water?

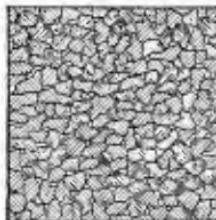
5. Fill two glass jars with moist, well-packed soil. Smooth the surface of one and let it form a crust. Keep the second covered to the depth of an inch with loose soil. Weigh. At the end of a week, weigh again and examine the condition of the soil in each.

SOIL VENTILATION

Uses of Air.—As has been already said, it is as important to admit air to the soil as to remove surplus water. Few plants can flourish unless air is admitted to their roots. The air is of benefit in several ways. Plants need the oxygen to breathe; the cär'bon di óx'ide works in the soil, preparing plant food.

Under-ventilated Soils.—There is a great difference in the natural ventilation, or airing, of soils. Stiff clay soils are poorly ventilated. They are so compact, or close, that they do not admit the air freely; in wet seasons or regions the water stands and chokes the air spaces. Such soils need drainage. As water is drawn out, air is drawn in by suction. Drainage allows roots to penetrate deeper and range more freely; these roots open channels for water and air. Tillage, or cultivation, also helps ventilate the soil.

Over-ventilated Soils.—On the other hand, coarse, sandy soils are often too thoroughly ventilated. Air and water pass freely through and carry away plant food; because of this loss of plant food, sandy land is often poor. Such a soil needs to be kept firm, except for a soil-mulch to protect it against loss of moisture by evaporation.



SOIL PARTICLES
AND SPACES

EXPERIMENTS

1. Put in each of two bottles of water a cutting of wandering jew, or some other easily rooted plant. Pour melted wax into one bottle, so as to cover the surface of the water and exclude air. What is the result?



To the cutting on the left, air is freely admitted; it is excluded from that on the right by melted wax poured over the surface of the water.

2. Put a flourishing plant in a tin can of fertile earth. Keep it flooded with water and notice the result.

SOIL TEMPERATURE

Conditions affecting Climate. — Soil temperature, or its condition with regard to heat and cold, is determined chiefly by climate. Climate, you know, is affected by many things, — nearness to the ocean, ocean currents, height above sea level, distance from the equator, prevailing winds, and the presence or absence of forests.

Conditions affecting Soil Temperature. — But there is often difference in the temperature of soils exposed to the same climate. The slope of land affects its warmth. A field that slopes to the south receives more of the sun's heat waves than one inclining to the north, and so is warmer. Color affects temperature. A dark soil is warmer than a light one, as a black dress is warmer than a white one; the dark color absorbs more heat waves.

A wet soil is colder than a dry one. Many of the heat waves which fall on wet land are spent in evaporating its surplus water; the heat waves on a dry soil are used to raise its temperature. You have probably had a personal experience which illustrates this. Were you ever caught in the rain and compelled to remain awhile in your wet clothes? It may have been summer, but unless you

kept yourself warm by exercise, you became chilled. This was because the heat which would have kept your body comfortable was being used to evaporate the water from your clothes.

EXPERIMENTS

1. Take three boxes of the same size and fill one with dry sand, one with dry clay, and one with dry loam. In each insert a thermometer to a depth of two inches. Take the temperature at 9 A.M. Set the boxes in the sunshine and take the temperature at 12 M. Put in the shade and take the temperature at 4 P.M. What differences do you notice?
2. Put a cupful of dry sand, one of wet sand, and one of water on a warm stove. Which becomes warm first and which last? Why?
3. Take the temperature at midday of the soil two inches below the surface in a wet, undrained field and in a well-drained field. What difference do you find? Explain the reason.

COMPOSITION OF THE SOIL

Elements. — We are apt to think of the objects around us as simple substances, but this is seldom the case. Plants, animals, the soil, and even most rocks are made up of several elements, or simple substances. These are mixed and combined in different ways so as to produce very different results. Strange as it seems, it is none the less true, that our bodies, a blade of grass, and the dust under our feet are composed of almost the same elements. Chemists have proved this by separating these compound substances into the simple ones composing them. As the farmer measures wheat and the grocer weighs flour, so the chemist measures and weighs the elements of the soil, air, and water, of plant and animal bodies.

Elements as Plant Food. — Although we may never wish to separate and examine them as does the chemist, it is well for us to know something about these elements. We are interested in the

earth-crust as the source of plant food, and it is these which supply that food.

In Nature's vast storehouse, most of the elements needed by plants are placed within their reach, in bountiful quantities, but sometimes one or more are lacking. The farmer who understands this subject can supply the needed elements, and by thus feeding his crop—or fertilizing it, as we say—can increase its yield.

Let us consider, then, some of the elements in the earth-crust.

Metallic Elements.—Six important elements of the soil are metallic,—iron, căl'ci um, mag nē'si um, po tăs'si um, sō'di um, and al ū min'i um.

Iron is an important element everywhere abundant. It forms from one to four per cent of the soil.

Calcium is a yellowish metal. It is found in limestone.

Magnesium is a hard, white metal.

Potassium is a soft, whitish metal. With ōx'y gen it forms pōt'ash, which is a compound of great importance in agriculture.

Sodium is a soft, light metal, resembling potassium in appearance.

Aluminium is a hard, white metal, like silver in appearance.

Nonmetallic Elements.—The most important and abundant nonmetallic elements of the soil are sīl'i con, sūl'phur, phos-phor us, chlō'rīne, oxygen, hȳ'dro gen, nī'tro gen, and car'bon.

Silicon is the second most abundant element in the earth's crust, of which it forms from one fourth to one third.

Sulphur is a pale yellow substance.

Phosphorus is a soft, yellowish substance. It is usually found in small quantities in the soil, and its lack is soon felt by plants.

Chlorine is a gas of yellowish green color and disagreeable odor.

Oxygen is a colorless gas, the most plentiful element in nature. It forms one half of the earth-crust, one fifth of the air, and eight ninths of the water.

Hydrogen is another colorless gas, the lightest known substance. United with oxygen it forms water, one of the most important and abundant compounds in nature. Without water, plant and animal life cannot exist.

Nitrogen is a colorless gas which forms four fifths of the air. It is necessary to both plants and animals.

Carbon, which exists in the earth-crust in three forms, is found in plants and animals, often in large quantities. Plants, however, get little carbon from the soil. They take most of their supply from the carbon dioxide of the air, a gas formed by the union of oxygen and carbon.

Compounds. — Few of these elements are found separate, or free, in the soil. Usually they are combined to form compounds.

Oxygen takes part in more compounds than any other element; it unites readily with almost all other elements. Nitrogen, on the other hand, takes part in very few compounds. We have learned that nitrogen is necessary to both plants and animals, but neither animals nor the higher plants have the power of using free nitrogen, — that is, nitrogen uncombined with other elements.

How, then, do they get their supply? Animals get theirs from plants, upon which they feed directly or indirectly. The nitrogen in the soil or the air is prepared for plant use by little organisms, called *bac te'ri a*, of which you will learn more later.

Fertile and Sterile Soils. — The particles of the earth-crust have been so mixed and combined by wind and water, by plants and animals, and by chemical action, that practically the same elements enter into the composition of all soils. A sterile soil is composed of the same elements as a fertile one. The fertile soil, however, contains all the elements necessary for plant food in sufficient quantity and in available forms, — that is, in forms which plants can use.

Some elements, such as aluminium, are not used by plants for

food. Others, such as chlorine, do not seem necessary to plant life; most plants flourish without them. Others, such as iron, are so abundant that even the poorest soils are well supplied.

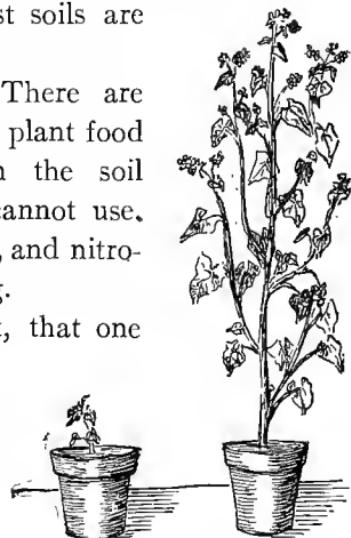
Elements sometimes Lacking. — There are three elements which are necessary for plant food and which are sometimes lacking in the soil or are found in forms which plants cannot use. These three are potassium, phosphorus, and nitrogen. More rarely, calcium is lacking.

If the soil lacks any one element, that one must be supplied. Without it a crop will not thrive, although all others may be abundant. The case is like that of a painter who is making a picture and needs several colors. He cannot paint his picture if you give him much blue paint and no yellow, when he needs some blue and some yellow. So Nature must have all her materials, the elements needed for crop growing.

Now, it is the farmer's aim to get from his soil the largest crop possible at the least possible cost. In order to do this he must know what his land needs and how to supply it in the most economical way. It is here that chemistry comes to his aid, as will be explained in the chapter on *Soil Improvement*.

EXPERIMENT

Take two ounces of pure sand and two ounces of rich wood mold. Heat each over an alcohol lamp and weigh again. The organic matter has been burned off; what remains is inorganic matter derived from the rock. What difference is there between the sand and the mold?



The buckwheat plant on the left is supplied with every element needed except potash; the plant on the right is supplied with potash also.

OUTLINE OF CHAPTER TWO

THE PLANT

Parts of a Plant :

Seed

Root

Stem :

Branches, twigs

Leaves

Blossoms :

Calyx, — sepals

Corolla, — petals

Stamen, — filament, anther, pollen

Pistil, — stigma, style, ovary

Duration of Plants :

Annual

Biennial

Perennial

Differences in the Parts of Plants :

Roots :

Taprooted, fibrous

Stems :

Upright, climbing, prostrate

Blossoms :

Perfect, imperfect

Pollen carried by wind, by insects

Seeds :

Scattered by plant, by wind, by animals

Plant Food :

Air-derived elements :

Carbon, oxygen, hydrogen, nitrogen indirectly through soil

Necessary soil-derived elements :

Iron, calcium, magnesium, potassium, phosphorus, sulphur

Plant Reproduction from Buds :

- Layering
- Cutting
- Grafting
- Budding

Transplanting :

Rules for success :

- Choose suitable season and weather
- Transplant young plants
- Do not injure the roots
- Prune the tops, if necessary
- Set firmly in moist soil
- Set no shallower and little deeper than they grew originally
- Use a mulch of straw, leaves, or loose earth

Plant Reproduction from Seeds :

How to obtain good seed :

- Select from plants in the field
- Consider each plant as a whole
- Choose vigorous, productive plants having desired qualities
- Select large, vigorous seed
- Dry them carefully
- Store them in a cool, dry place
- Examine seeds for purity and test as to vitality

How to Plant Seeds :

- Depth
- Soil condition
- Time

Plant Improvement :

Underlying principles :

Heredity, variation, selection

Methods :

Selection of seeds or buds, cultivation, crossing, hybridizing

CHAPTER TWO

THE PLANT

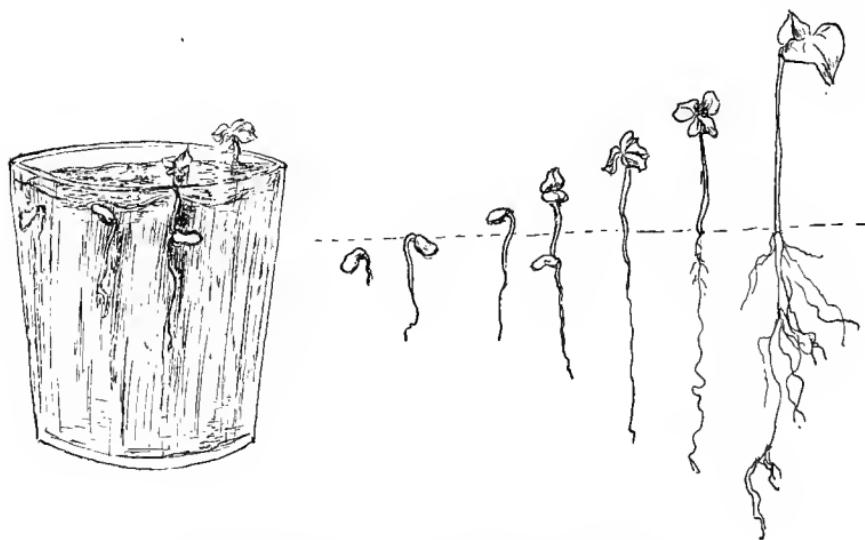
FROM SEED TO SEED

Seed and Plant.—Here is a seed, grayish green and fuzzy. Have you seen one like it before? If not, this seed brings to your mind only a vague, general idea. You know that under favorable conditions it will produce a plant, something green and living.

If you are familiar with this seed, you know just what kind of plant it will be, and how it will grow. It will be weak at first, and rather clumsy-looking when its crumpled seed leaves push through the soil. But it will grow strong and graceful, and throw out spreading branches like a tiny maple tree. It will become perhaps two feet, perhaps six feet, tall. It will put forth buds called 'squares'; then pretty cream-colored blossoms, changing with age to rosy pink; then fruit called 'bolls.' The bolls, at first green, will grow larger and turn brown. When ripe, they will open and yield a harvest of soft white fiber, the cotton of which our clothing is made. All this lies infolded in this grayish green, fuzzy seed.

If the question be asked, "For what does the farmer grow the cotton plant?" you answer readily, "For the sake of its fiber." You know that, because his chief care is to save and use it. But if you are asked why Nature raises the cotton plant, you find it more difficult to answer. It is not for the graceful plant, nor the pretty blossoms, nor the soft fiber. She lets all these return to the soil. One thing she saves and uses, — the seeds inwrapped in the fiber, the seeds which bring forth new plants.

Cotton Plant. — Let us follow in detail the life history of a cotton plant. It is a pretty and interesting plant, which less than two hundred years ago was grown as an ornament in flower gardens. Now it is one of our chief agricultural crops. It is a good plant with which to begin our study of agricultural plants on account of its perfect and conspicuous blossom, its regular habits of growth,



GERMINATING COTTON · STAGES OF DEVELOPMENT

and the way in which man has influenced Nature in its development.

Seed Development. — Cut open a cotton seed and examine it carefully. Wrapped in a hard covering or hull are a germ, or minute plant, and food to support the plant until it can put forth roots and get food for itself from the soil.

How can we help the little plant come forth from the seed? It must have help from outside. We know that we may keep seeds year after year, and they never develop into plants. To make

them germinate, they need three things,—moisture and warmth and air. Let us supply these. Put some cotton seed in a flower-pot filled with fertile soil. Keep it moist and warm, and your seeds will germinate and develop into plants.

In the soil, however, you cannot watch the development as you would like to do. For this purpose, let us use a glass. Fill it with soil, and plant cotton seed next to the glass. Fasten paper or cloth around the outside, to exclude the light ; keep the soil moist, and the glass in a warm place. The seeds will germinate more quickly if they are soaked twenty-four hours before they are planted.

How Plants Grow.—As a seed absorbs moisture, it swells. Then it puts forth a tiny shoot, the first root ; from the other end of this, after a while, it puts forth the beginning of the stem. The first tiny shoot turns downward into the soil, never by any chance making a mistake and growing upward. The stem goes upward into the air and sunlight as surely as the root goes downward into the soil and darkness.

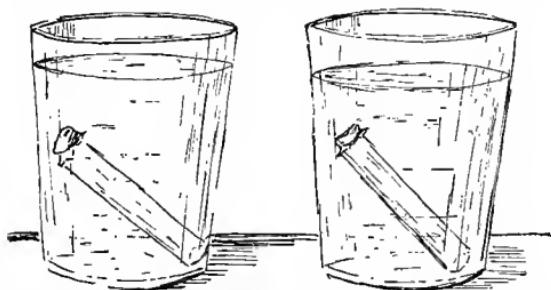
We said that the store of nourishment in the seed enables the plant to put forth its root and stem. But that store is soon exhausted, and the little plant must get food for itself. This is, in part, the work of the root.

How Plants Feed.—The cotton plant has what is called a tap-root, a long, straight main root. From this grow branch roots, which divide and subdivide into rootlets, from the ends of which grow hundreds and thousands of root hairs. These are like tiny hands reaching out for water and food.

Plant Food from Soil.—But what is plant food? Why, it is the elements of which you learned in the chapter about *The Soil*. Some of these elements — nitrogen, sulphur, phosphorus, potassium, calcium, magnesium, and iron, in compounds which the

plant can use — are dissolved in the films of water which, as you learned, surround soil particles.

Osmosis. — But the roots have no mouths or openings through which to take in food. How, then, do they get it? The root hairs take it in by os mō'sis. That is the scientific name for the passing of substances through a membrane, or layer of covering tissue. By a simple experiment you can observe the working of this force.



The bottle on the left and the glass on the right contain sirup; observe how the membrane covering the bottle is pushed out on the left and in on the right by osmosis.

Fill a small bottle with a sirup made of sugar and water, and tie over the mouth a piece of softened bladder or the membrane of the white of an egg. Invert this bottle in a glass containing clear water. In a little while the water will be sweetened by

the sirup which osmosis causes to pass through the membrane. Reverse the experiment, putting clear water in the bottle and sirup in the glass; again the sirup is drawn through the bladder into the water. So, by osmosis, the water containing the dissolved elements passes through the membranes of the root hairs.

Do you think that the hungry roots feed at once upon this sap, as it is called? No, it is not yet ready for them. It must be prepared for plant use, as our food must be prepared to nourish our bodies. The leaves are often called the stomach of the plant, because it is in them that the sap is prepared for plant food.

How Sap Rises. — Do you wonder how the sap gets from the roots to the leaves? Osmosis, capillarity, and transpiration all aid in pumping it up. You can observe for yourself the working

of these forces. Take a lily, snowball, or other white flower, and put the stem in a vase of water colored with red ink. The reddened water is drawn up through the stem, and colors the flower.

Plant Food from Air. — We know that a plant absorbs food through its roots. This is important and necessary. If you cut off the root, the part of the plant above ground will die for lack of nourishment. But by far the greater part of its food — about ninety-five per cent — is derived from the air. Wonderful it is, yet true, that from the invisible air, to a large extent, the plant builds up its substantial body. The elements derived from the air are carbon, oxygen, hydrogen, and nitrogen. Carbon dioxide, which is carbon and oxygen, is taken in by the leaves. Oxygen and hydrogen, in the form of water, pass down into the soil and are taken in by the roots. The nitrogen, in compounds prepared chiefly by bacteria in the soil, also enters through the roots.

A Leaf. — Let us examine a leaf under a microscope. It is composed of cells which are as colorless as glass. Stored in these cells is a green coloring matter called chlō'ro phyl, or leaf green, which is formed from iron salts in the sap. Wherever there is greenness in the plant, there is chlorophyl, — in stems and branches, but especially in leaves. Chlorophyl can be formed only in sunlight. That is the reason a plant which grows in a dark place is pale and colorless. How much prettier is the green plant! But the green coloring matter is not for beauty alone, though we may well believe this is one of the purposes of our Heavenly Father, its Creator.

On the leaf, chiefly on the under side, are many little openings or mouths. Through these it takes in the carbon dioxide of the air. By the action of chlorophyl and of sunlight, this gas is separated into oxygen and carbon. Most of the oxygen is returned to

the air by the leaf. The carbon is retained for food. But it is not used in its pure form. It is united with the oxygen and hydrogen of the sap to make starch and sugar. These substances form plant food. All parts of the plant — stem, branches, leaves, and root — are nourished by food formed in the leaf laboratory from elements gathered from the soil and the air.

Need of Sunlight. — The two processes, the formation of chlorophyl and the changing of carbon, oxygen, and hydrogen into starch and sugar, cannot take place without sunlight. The plant is like a machine run by a motor, the sun. All parts of the machine may be perfect and in readiness, but their work does not proceed unless the motor is in action.

Need of Water. — Leaves perform other work besides taking

in and preparing food. It requires a great deal more water to carry food from the roots to the leaves than is needed by the plant in its growth. The surplus water is transpired, or given out, by the leaves, and so returned to the air. Experiments prove that a plant uses several hundred pounds of water in forming one pound of dry matter.

Amount of water used in producing one pound of dry matter

POTATOES	1,778 POUNDS
OATS	1,208 POUNDS
WHEAT	1,049 POUNDS
CORN	753 POUNDS

Most plants thrive best when they have much sunshine and frequent showers. In wet seasons, they suffer for want of sunlight; in dry ones, they lack water. The cotton plant is a native of the tropics, and it loves warmth and sunshine. It does not thrive in cold, wet weather.

Sap. — The food prepared in the leaves goes to all parts of the cotton plant. It passes through the soft, fibrous layer called the

căm'bi um, which is between the hard outer bark and the woody stem. It is diffused throughout the plant, and causes the cells which compose it to increase in size and in number,—that is, it causes the plant to grow.

Cells.—If you examine the stem, leaves, and roots of a cotton plant under a microscope, you find that they are made up of many parts of different shapes and sizes. These parts are called cells. Old cells contain water and air; in young, active ones, there are water and a jellylike substance called *prō'to plasm*. This is a very wonderful substance. The wisest men cannot tell you what life is, but by long and patient study they have learned that the life of a plant or an animal exists in this substance called *protoplasm*.

Plants of a low order, such as the bacteria of which you will



BUD AND BLOSSOM OF THE COTTON PLANT

learn more later, consist of a single cell, a simple wall containing protoplasm. But plants of a higher order, such as the cotton plant, consist of many cells, connected more or less firmly.

Flower. — Week after week passes. The leaves and branches of our cotton plant grow larger, and new ones are formed. It puts forth buds. These open into pale yellow blossoms. The pretty, graceful flowers are a delight to the eye. Of these, also, we feel that beauty is one of their purposes, though not their chief one.

Let us examine one of these blossoms carefully. We find that

it has four parts. These parts are made up of leaves changed in form to adapt them to the special work that they have to do.

Calyx. — There is a cup-shaped green covering at the base of the blossom. This is called the *cā'lyx*. You will observe that this calyx is five-parted. These



COTTON BLOSSOM

Outside, showing calyx; inside, showing stamen and pistil.

parts are called *sē'pals*. In some plants the sepals are separate leaves; in others, as in the cotton, they grow together. The calyx is usually, but not always, green.

Corolla. — The blossom cup is called the *co rōl'la*. The corolla, like the calyx, is separated into five parts joined at the base. The parts of the corolla are called *pē'tals*. Often, as in the cotton blossom, the corolla is more delicate in texture than the leaves and is different from them in color. The calyx and the corolla are the most showy parts of the blossom, yet they are only coverings for the necessary parts, the organs in the center.

Stamens. — Next to the corolla are the organs called stā'mens. Each stamen is composed of three parts: the fil'a ment, which is the stem; a knob on the end of the filament, called the än'ther; and the fine dust in the anther, called the pō'l'en. This dust is yellow in the cotton and in most other plants.

Pistil. — In the center of the flower is an organ called the pī'stil. Like the stamen, a complete pistil is made up of three parts. The enlarged top is called the stīg'ma. Below this is a stem called the style. This connects the stigma with the enlarged base of the pistil, called the ō'va ry. The ovary contains the ō'vules, which later form the seeds. A grain of pollen dust falls on the stigma and puts out a thread finer than the finest thread of a spider's web. This grows through the style into the ovary, carrying life to the ovules. The ovules are then said to be fertilized. If pollen dust fails to reach the stigma, the ovules are not fertilized and they do not mature into seeds.

Boll and Seeds. — After a day or two, the corolla of the cotton plant turns pink. Then it shrivels and falls. The ovary develops into the fruit, or boll, containing seeds. Larger and larger grows the boll, green at first, then turning brown. When ripe it opens, disclosing locks of soft white fiber. Wonderful as it seems, this fiber is almost pure carbon, like the coal we burn. It is made by the plant out of the carbon of the air. Its threads, single cells about an inch long, grow on the seeds. The boll has three or five divisions, each containing several fiber-covered seeds. To produce these seeds is the



AN UNOPENED COTTON BOLL

life purpose of the plant. As soon as they mature, its work is done. Its roots cease to take in food and water, its leaves cease to manufacture starch and sugar, and the plant dies.

Annuals. — This is the life history of an *ăn'nu al*, such as our agricultural cotton, which lives only one year and produces one crop of seed.



AN OPENED COTTON BOLL

Biennials. — Some plants, such as the turnip, do not produce seed the first season. They make a part of their growth one summer, live through the winter, blossom and produce seeds, and die the second year. These plants are called *bi ēn'ni als*.

Perennials. — There is a third class of plants called *per ēn'ni als*, which take still longer to make their growth. They live three or more years, usually growing in the summer and resting in the winter.

Perennials often bear many crops of seed; sometimes, as in the case of the oak, they are slow of growth and live many years before they begin seed bearing.

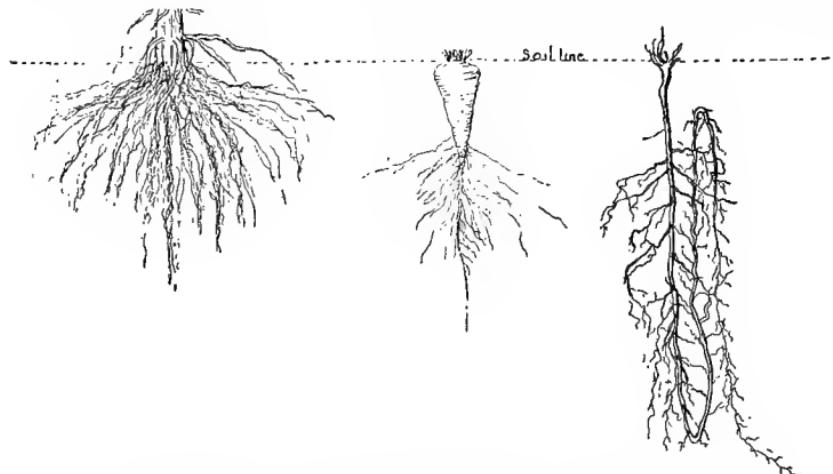
It is an interesting fact that cotton is by nature a perennial. But the plant that grows in our field is an annual. It has been made so by the work of man. He has used conditions of soil and climate, culture, and fertilizers to shorten its period of growth, and thus change it from a perennial to an annual. Later, we shall learn more of the influence of man on the development of our agricultural plants.

EXPERIMENTS

1. Get large, simple flowers, such as apple blossoms and morning-glories. Take them apart so as to see the different parts.
2. Examine germs and germ food in seeds. To do this, put large seeds, such as beans or corn, in warm water and let them soak twenty-four hours; then slip off the outer skin.
3. Plant some grains of corn in moist soil and some in dry soil, and keep both in a warm place. What is the result? What does this prove as to the requirements for seed germination?
4. Plant corn in two boxes of moist soil and keep one in a cold place and the other in a warm place. What is the result? What does this prove that seeds require?
5. Plant some grains of corn in moist, firm soil and some in wet clay, of which the surface is kept packed and wet so as to exclude air. What is the result? What does this prove that seeds require? Experiments 3, 4, and 5 can be made with seeds put between layers of blotting-paper, which is kept dry, moist, or saturated with water.
6. Try experiments 3, 4, and 5 with growing plants, and observe the results in each case.
7. Perform the experiment described on page 38 to show the working of osmosis.
8. Put the same amount of water in each of two glasses. In one glass put a branch of clover or some other plant. Examine the two glasses every day for a week. What difference is there in the amount of water in each? What has the plant done with the water? Perform experiment 4, page 26.
9. Cover green grass with a small board. What effect has this covering on the color and growth of the grass? Cover a branch of a plant with dark paper so as to exclude light. Examine in three days. What do these experiments prove about chlorophyl?
10. Pour iodine diluted with water on a piece of cornstarch. You will see that iodine turns starch blue. Take a leaf which has been uncovered, and one which has been covered, as in experiment 9; soak both in alcohol, and then pour diluted iodine on them. What difference is there? What does this prove that the leaf requires in order to form starch?
11. Make a list of common farm annuals; biennials; perennials.

DIFFERENCES IN THE PARTS OF PLANTS

Main Parts of Plant. — You have learned from your study of the cotton plant that the main parts of a plant are root, stem, leaves, blossoms, and seeds. Each of these parts has its special work to do for the whole plant. The root supports it in the soil, and receives

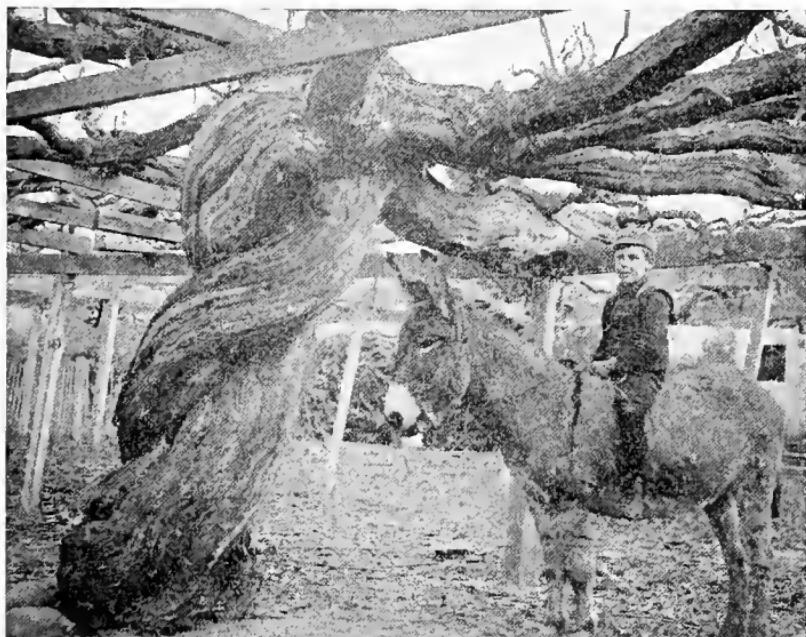


Corn, a fibrous root; beet, an enlarged taproot; alfalfa, a long taproot.
ROOT SYSTEMS

and carries food and water. The stem and branches are channels through which the sap is diffused to the different parts of the plant. The leaves are laboratories in which the sunlight makes plant food out of the elements collected from air and soil. The blossoms contain the organs necessary to reproduce the plant and to continue the life of its kind on the earth. The seed is the result of the work of these organs.

Taproot. — The cotton plant has, as we have learned, what is called a taproot. The first root grows and enlarges into one main root with branch roots, rootlets, and root hairs. Among taprooted

plants are the oak, tobacco, and thistle. What are called root crops, such as turnips, beets, and parsnips, are biennials with taproots. During the first season, their roots store up food, in the form of sugar and starch, for the plant to use the second season.



A CLIMBING STEM

This California grapevine is probably the largest in the world. The vine yields every year about ten tons of grapes.

Instead of drawing from the soil for the latter part of its growth, the plant uses this store laid up in itself. If you examine a turnip root after the plant has made its second season's growth, you find that it is a mere shell, almost empty of nourishment.

Fibrous Roots. — Instead of a taproot, some plants have fibrous roots, a number of roots extending in all directions. These, also,

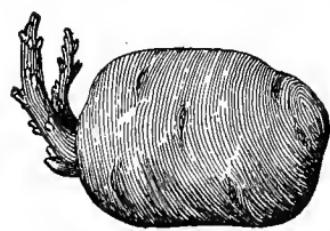
branch and subdivide into smaller roots, rootlets, and root hairs. Cereals and grasses are fibrous-rooted plants. Sometimes fibrous roots enlarge and store up sugar and starch. Sweet potatoes, for instance, are enlarged fibrous roots.

Weak- and Strong-Feeding Plants. — Roots differ greatly in their power to take in food from the soil. Some plants are very weak feeders. For them to thrive, the soil must be carefully prepared, and food must be near in available form. Strong-feeding plants have much greater power to collect food and require less care, though no agricultural plant will thrive on neglect. Wheat is a weak feeder and corn is a strong feeder, belonging to the same great family of cereals, or grain plants.

Stems. — The stem bears the branches, with the leaves, blossoms, and seeds. It is the channel for the sap. Stems vary greatly in appearance. Usually, as in the case of the cotton plant, they are stiff enough to hold the plant upright. Vines, such as the grape-vine and ivy, have stems which climb on some support. Melons, such as the watermelon, have prostrate stems, which lie upon the ground. Sometimes the stem, or a part of it, grows underground. This is the case with Bermuda grass. The white, or Irish, potato is

an enlargement of an underground stem.

Parts of Stem. — In most stems there are a woody, fibrous matter, a cambium, or inner bark, and a thick outer bark. In the center of the stem of long-lived perennial trees there is a layer of old tissue, or heartwood, through which there is little movement of sap.



A white potato — an enlarged underground stem

Girdling Plants. — If a plant is girdled, or has its outer bark and cambium cut off all around, the top does not wither and die at once, as it does if its roots are cut. Sap still mounts upward

through the wood, is changed to food in the leaves, and feeds the upper part of the plant. But it cannot go below the girdled cambium to feed the roots. Sooner or later—in the case of a tree it may be several months—the roots die of starvation. A farmer often girdles in summer trees that he wishes to kill; they die entirely, root first. If they were cut down, the roots might still live and send up new growth year after year.



AN EAR OF CORN, THE 'SILK' OF WHICH WAS NOT FERTILIZED BY POLLEN FROM THE TASSLES OF ANOTHER PLANT

Leaves.—You have learned that leaves are formed of clear cells containing a green coloring matter called chlorophyl, and that they manufacture food for the plants. Therefore you realize that the presence and health of the foliage are very important. If it be destroyed, as by disease, the whole plant will suffer and perhaps die. If crops are shaded by trees or weeds, the manufacture of plant food in the leaves is hindered for lack of sunlight.

Sugar and starch are stored up in some leaves, as they are in some roots. It is this store which makes the leaves of cabbage valuable for food.

Underground Leaves.—There are underground leaves as well as underground stems. They are never green in color, because

the sunlight, which is necessary to form chlorophyl, cannot reach them. Bulbs, such as the lily and the onion, are thickened, underground leaves crowded together on a shortened stem.

Perfect Flowers. — The cotton is a plant with a perfect flower,— that is, the blossom has calyx, corolla, stamens, and pistil. One blossom can fertilize and produce seeds.



Perfect and imperfect strawberry blossoms. The one on the left has both stamens and pistils, the one on the right has pistils only.

Imperfect Flowers. — Some plants have imperfect flowers in which one or more of these four parts is lacking. Some lack the calyx, or the corolla, or both; some bear stamens and pistils on separate blossoms. Did you ever

think of the tassels and the ear as the blossoms of the corn? That is what they are. The tassels are the stamen-bearing flowers, and the yellow dust on them is pollen. The ear is the pistil-bearing flower and cannot ripen grain unless pollen falls on its silk, which is the ends of its pistils. Sometimes the pistil- and the stamen-bearing blossoms are on different plants. This is the case with the hop and with many varieties of strawberries. Pistil-bearing flowers cannot bear fruit and mature seeds unless they are fertilized by stamen-bearing ones. Plants which bear only stamens never produce seeds.

Pollen Carrying. — One plant cannot leave its place in the field and carry its pollen to another. How, then, is it conveyed? The two chief ways are by means of the wind and by means of insects.

By the Wind. — Pollen is so light that it is easily and often carried a great distance by the wind. It is to prevent the wind from bearing the pollen of one to another, that farmers plant dif-

ferent varieties of corn far apart. If pop corn is planted near field corn, they will 'mix,' as farmers say, and grow alike."

The wind is a very wasteful messenger. It scatters pollen on the ground and over other plants. Plants that depend upon the wind as their pollen bearer need to produce a great deal. As a rule, plants with wind-borne pollen have small, scentless flowers, and light, dry pollen. Such are the grasses.

By Insects. — Some plants depend on winged insects to carry their pollen. Insects, as you know, are busy little workers. They labor to provide food for the day and also for the morrow. They do not carry pollen for nothing. The plants pay them by giving food—nectar or pollen—and it is to get this that the insects visit flowers. The blossoms' gay colors or sweet odors are signs that they have food to give for pollen bearing. When an insect gets food from a flower, it is dusted with pollen. This is deposited on the stigma of the next flower that it visits. Flowers which depend on insects as pollen bearers do not provide as much as do those that depend on the wind, because it is carried with much less waste.

By Hand. — Pollen can be transferred by hand, and this is one of the methods which is used to produce new varieties of plants. The blossom that it is desired to pollinate is kept covered to prevent its receiving pollen from any other source. Pollen is carefully collected from another plant and put upon the stigma. By hand-pollination valuable breeds of wheat, oats, corn, and other agricultural plants have been obtained.



A bumblebee getting nectar and pollen from red clover

Seed Sowing. — To have their seeds sown, plants resort to many methods. Sometimes a plant scatters its own seed. This is the case with the balsam, or touch-me-not. If you touch a ripe seed pod, it pops and throws its seed some distance. Sometimes the wind acts as seed bearer. In that case the seeds are very light, such as those of the dandelion and thistle. Sometimes animals convey seeds. Those with hooks and burs, such as beggar weed and cocklebur, stick to the wool or fur or hair of animals, or to the clothing of people, and make them unintentional and often unwilling seed bearers. Plants sometimes treat higher animals as they do insects, and pay them to carry seeds. Berries and orchard fruits have juicy, fleshy coverings. These are used for food, and the seeds are scattered.

Plants as Food Makers. — Seeds, as you learned, contain not only a germ, or little plant, but also a store of nourishment to support the germ in its first stages of plant life. Some seeds, such as those of wheat, oats, barley, rice, and corn, are rich in starch; these furnish food for man and beast. Some seeds, such as those of the poppy, flax, and cotton, are rich in oils; they are used to produce oil for illumination, paint, varnish, medicine, food, and other purposes.

Did you ever consider that plants are the only real food makers in the world? Out of inorganic material they form sugar, starch, oil, and other compounds, which they store up in their roots, stems, leaves, fruit, or seeds. From this source, man and the lower animals derive, directly or indirectly, all their food.

EXPERIMENTS

1. Collect and compare the stems, roots, leaves, blossoms, and seeds of as many agricultural plants as you can get.
2. To see the extent of a root system, grow clover plants in a box of

mellow soil. Then remove the bottom of the box and soak the soil away so as not to break the roots.

3. To see how biennials feed on their root-store of food, put a Chinese lily bulb in a pan of water in a sunny place. See how as it blooms it 'eats up its own root.'

4. Girdle a branch of a worthless tree and observe what happens.

5. Watch flowers and see what are their insect visitors. Can you think of any reason why a bee is a better pollen-bearer than an ant?

6. Examine strawberry blossoms to find perfect and imperfect ones. Keep a plant with an imperfect flower covered during blossom time so as to exclude insects. Does it bear fruit?



ILLUSTRATION OF EXPERIMENT 7

The three plants on the left are from whole grains of corn; the three on the right are from grains from which most of the germ food was cut.

7. Take some grains of corn of about the same size, and from half cut off most of the germ food, being careful to leave the germ uninjured. Plant the grains and observe the difference in germination and growth of the plants from cut and uncut grains. What does this experiment teach as to use of germ food and as to relative value of large and small seeds?

PLANT FOOD

Plants' Need of Food. — You know that an animal must have food; did you ever consider that food is as necessary to a plant as to an animal? Every living thing needs food to keep it alive and to make it grow. But, you say, we did not feed the cotton plant. We did so indirectly. We planted the seed and cared for the young plant so that it could get food from its two great storehouses, the soil and the air. Sometimes, however, we have to do more than this. We have to supply to our crop-plants elements that they need, and in order to do this we ought to know what these elements are.

Chemists have analyzed plants and separated them into the elements of which they are composed. Thus they have learned what is needed to make them grow and develop. All of the elements which exist in the soil are not necessary to plants.

Necessary Elements. — There are ten which are necessary for plant growth. These are oxygen, hydrogen, carbon, nitrogen, iron, phosphorus, sulphur, calcium, magnesium, and potassium. We cannot say that any one of these is more important than another. If the plant be deprived of any one, it will die.

Air-derived Elements. — The elements oxygen, hydrogen, carbon, and nitrogen are derived directly or indirectly from the air. They form about ninety-five per cent of the plant's body.

The oxygen and hydrogen are taken in chiefly in the form of water. It dissolves solids, liquids, and gases, and carries food to plant roots.

Carbon composes about half the solid matter of a plant. It forms a small quantity of the air,—only about one part in twenty-five thousand,—but the amount in the whole volume of

air is enormous. Great as are plant demands upon it, there is no danger that the supply will ever be exhausted.

Nitrogen, which is necessary to all living things, cannot be used by the higher plants until it is prepared in certain compounds. Most plants get their nitrogen as nitrates, compounds prepared by bacteria in the soil. A class of plants, called legumes, can use the nitrogen of the air indirectly by means of bacteria which live in knots, called tubercles, on their roots.

In one way or another the nitrogen, without which all living things would starve, is prepared by bacteria. Later on, you will learn more about these bacteria. They are the smallest known living organisms, and are so tiny that they are visible only under a powerful microscope; their very existence was unsuspected until recent years.

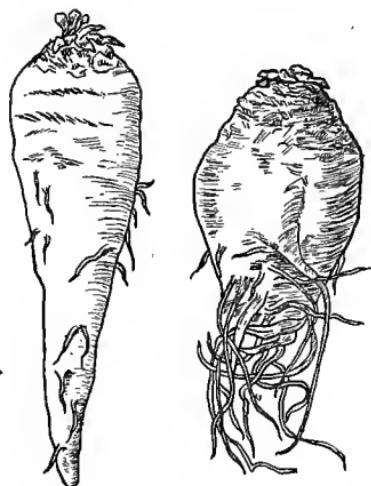
Soil-derived Elements. — The plant derives from the soil only about five per cent of its food; but, small as this portion is, the plant cannot live without it. The necessary soil-derived elements are iron, sulphur, magnesium, calcium, phosphorus, and potassium. Of these elements, four — iron, sulphur, magnesium, and usually calcium — are abundant in most soils. As has been said, nitrogen, phosphorus, and potash sometimes exist in soils in limited quan-



Roots of soy bean, showing tubercles,
slightly reduced in size

ity. If present, they are often in forms which the plant cannot use.

A chemist will analyze a piece of granite and tell you that it contains all the elements needed for plant food. But they are locked up in forms which the plant cannot use; they are 'unavailable,' we say. The plant can no more feed on them than we can clothe ourselves in the cotton fiber in the boll, or than we can make bread of unhusked corn.



The beet on the left was grown in mellow, well-tilled soil; that on the right was grown in rough, hard clay.

Soil Texture.—Even in soil well supplied with plant food, crops may not thrive. The soil texture may be unfavorable. You have learned something about the differences in soils and how texture affects relations to water, air, and heat. You have learned also, that these three things have an important influence on the growth of plants. You understand, then, that while sand, clay, and humus furnish little plant food, they affect plant growth and crop yield.

Each kind of soil has vegetation especially adapted to it. A sandy soil, if well supplied with plant food, is adapted to tubers and root crops; it yields up plant food fully and freely, and the growing roots easily push its particles aside. Clay soils are adapted to grain and grass crops and to other plants with fine, fibrous roots that can make their way among the tiny particles to collect plant food and water. Certain plants, such as blue grass, thrive best in a limestone soil. The limestone region of Kentucky

is often called 'the blue grass country.' Nearly all plants flourish on a mellow loam, because it is well supplied with moisture, warmth, and air.

EXPERIMENTS

1. Weigh a plant, such as cotton. Put it in the stove and let it dry thoroughly. Then weigh again. What has the plant lost? Take off the leaves and weigh them. Burn them and weigh the ashes. Weigh the stem, and then burn it and weigh the ashes. The ashes are the soil-derived elements. What difference is there between the quantity in leaves and in stem?

2. Burn an equal weight of dry straw and dry tobacco. What does this experiment show as to the composition of plants?

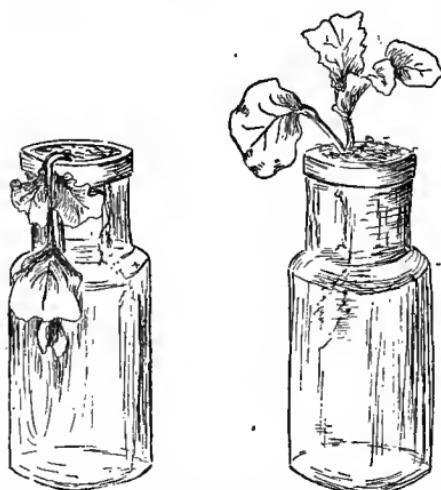
3. Put some grains of corn in a bottle of pure distilled water. What happens as soon as the plants use up the store of food in the seeds?

4. Put in another bottle water supplied with plant food in the following proportions:—

Distilled water 1000.0 grams
 Potassium nitrate 1.0 grams
 Calcium phosphate .5 grams
 Calcium sulphate .5 grams
 Magnesium sulphate .5 grams
 A trace of iron sulphate

Put some grains of corn in this water. Renew the solution frequently and keep the bottle covered with dark paper. Prepare other bottles of distilled water, omitting one or more of these food elements. What are the results? Use all the elements with one fourth this quantity of water. What does this prove about the oversupply of plant food?

5. Collect legumes and examine tubercles on the roots.



The plant on the right is supplied with plant food in the proper amount of water; the plant on the left has similar plant food in one fourth the amount of water.

PLANT REPRODUCTION FROM BUDS

• **Buds.** — Plants are usually grown from seeds, but it is sometimes easier and better to grow them from buds. Every branch ends in a bud, and buds are also found at regular places on the branch. These buds which continue the growth of the old plant can be used to make new ones. A budded plant is sure to be like its parent plant, because it is a part of it.

There are cases in which it is not only desirable, but necessary, to grow plants from buds, in order to preserve the variety. Some plants do not 'come true to seed.' An apple seed, for instance, instead of producing a tree that bears fruit like the one from which it was taken, is more apt to produce one resembling the wild crab from which it originated.



Methods of Bud Reproduction. — There are various ways of reproducing plants by buds, — by *lāy'er ing*, *cūt'tings*, *grāft'ing*, and *būd'ding*. In all cases the purpose is the same: to produce from a part of an old plant a new one that reproduces its characteristics.

Layering. — In layering, there is used a shoot which grows from the root of the plant. Earth is placed over the stem of this, and usually the tip is left out to continue its growth. At first it receives nourishment from the parent root, but after a while the covered

stem sends forth a root of its own. Then it is separated from the parent.

Layering is an easy and successful way of reproducing most plants which send up shoots from the roots. Some plants, such as the raspberry, increase naturally by layering.

Cuttings.—For cuttings, there are used pieces of stem which contain one or more good healthy buds. These cuttings are rooted



A DORMANT CUTTING



A GREEN CUTTING

in water, in soil, or in fine, clean sand kept warm and moist. Roots grow from the end of the stem or from the base of a bud; a bud sends forth a stem, which becomes a new plant.

Sometimes the cutting does best if it is taken when the plant is *dormant*,—that is, when it is resting from growth, as fruit trees do in the winter. During the growing season, nourishment is stored up in the cambium and at the end of the twig to begin the growth next season. The cutting from a dormant

twig has this nourishment to help it make roots and growth of its own.

As you learned, the white potato is an underground stem. When we cut and plant potatoes for seed, we use a method of reproduction by cutting, just as when we make a cutting from the above-ground stem of the grape.



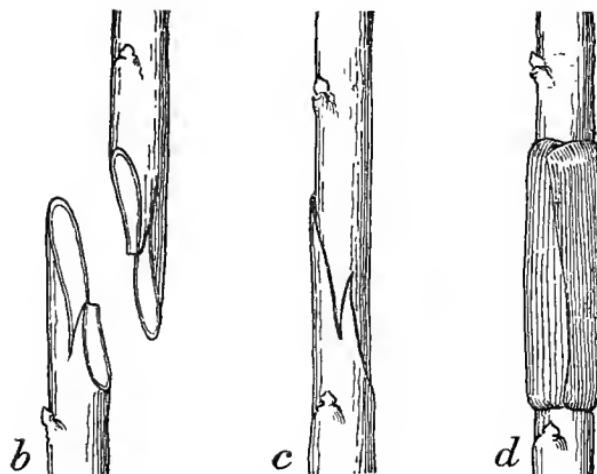
A coleus leaf cutting,
rooted

For some plants, such as geraniums, we use green cuttings,—that is, cuttings taken from the plant during its season of growth. At least half the leaves are removed, some being left to prepare plant food.

Grafting.—Grafting, also, is a method of reproduction by means of buds. In this case, however, instead of being grown in soil, the young plant is grown on the stem or root of another plant. Grafting has several advantages in the case of plants to which it is adapted. In the first place, it gives the new plant the benefit of a root system already established. In the second place, it has been found that certain plants are more vigorous and productive on other roots than on their own. In the third place, grafting can be used to modify habits of growth. A pear tree on a quince root is smaller, matures earlier, and is more productive than a pear tree on a pear root.

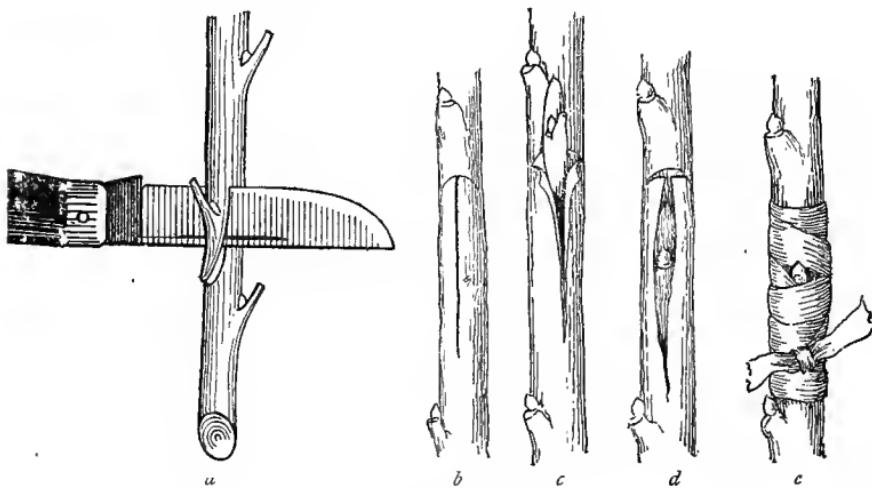
Grafting is done by inserting a twig of the desired variety on the root or stem of another. The plant food passes from the cambium of one to the other, and finally the two grow into one. Methods of grafting are described more fully in connection with orchard fruits, for which they are much used.

Budding.—Budding is a method of grafting where, instead



GRAFTING

b, separate parts of the graft; *c*, parts united; *d*, wax applied.

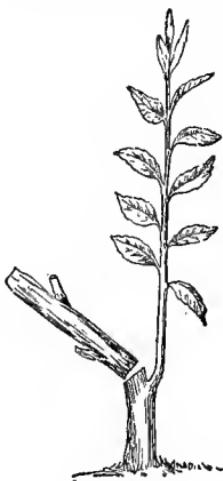


BUDDING

a, cutting off the bud; *b*, stock prepared by a T-shaped cut; *c*, inserting the bud into the stock; *d*, the bud inserted; *e*, the bud fastened in place.

of a twig, there is used a single bud of the desired variety. This is inserted into the stem of the plant upon which it is to be grown.

Budding, also, is more fully described in connection with orchard fruits.



A budded tree from which the top of the stock has just been cut.

EXPERIMENTS

Try to grow some plants from buds. You may not find it easy to grow plants by grafting and budding, but layering and cutting are less difficult. Be sure that you try to reproduce the best varieties.

1. Raise a strawberry plant and a grapevine by layering.
2. Raise a white potato and a geranium from cuttings. Do you use a green or a dormant cutting of the geranium? Why?
3. Bud and graft some seedling apple trees, using buds and scions from a good variety.

Do you use green or dormant cuttings? Why?

4. Why do you remove some leaves from a green cutting and why do you leave some?

TRANSPLANTING

Transplanting. — It is seldom the case that we wish to leave just where we reared it the plant grown from a bud by layering, cutting, grafting, or budding. When it has a root system of its own, we usually transplant it, or take it up and set it in another place. If this be done with care, most plants will live. They develop more roots and flourish better than those that are not transplanted. If transplanting be carelessly done, plants are very apt to die.

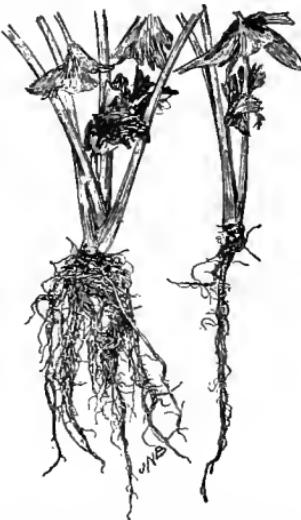
Rules for Transplanting. — There are a few simple precautions which give success in transplanting.

First: The most favorable season should be selected. In the case of such plants as tomatoes and sweet potatoes, transplanting should be done when the weather is cool and damp, preferably in the late afternoon.

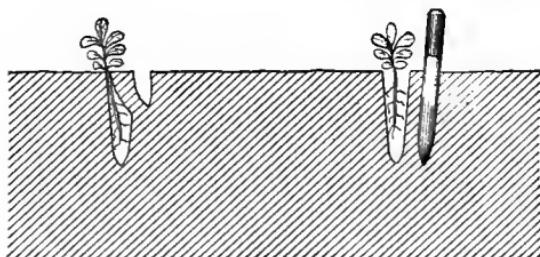
Second: A plant should be transplanted when young. It is more apt to adapt itself to new conditions and make vigorous growth.

Third: It should be taken up so as to break the roots as little as possible and should be kept moist and shaded. If the roots become dry, the plant loses vitality and may die.

Fourth: It is well to cut off some of the top, especially of a tree or large plant. In taking it up, roots are unavoidably broken.



The celery plant to the left was transplanted; the one to the right was not.



The plant on the left was improperly set; the soil is being pressed properly to the roots of the plant on the right.

Fifth: The plant should be dipped in water and have moist, fertile soil packed firmly around its roots. This enables them to

The root system is thus smaller, and it has to adapt itself to new conditions. It is unable properly to supply food to the whole plant. Therefore the top should be cut back to correspond with the smaller root and to give it time to reestablish itself.

absorb moisture and to begin as soon as possible to take food from the soil. The soil should not be too wet, as wet soil around the roots excludes air. Unless it be very dry, it is generally better not to use water except to moisten the roots. If water be used, it should be poured around the roots before all the soil is added. If it be applied to the surface, as the soil dries, it forms a crust which excludes air and hastens evaporation.



STRAWBERRY PLANTS

The plant on the left is set too deep, with its roots bunched; the one in the middle is set too shallow; the one on the right is set properly.

Sixth: The plant should be set as near as possible as it grew originally. It will usually do no harm to set it a little deeper. But it is not apt to thrive if it be set much deeper or much shallower than it originally grew. The hole should be deep enough and broad enough for the roots to spread out naturally without being bunched or bent. The surface soil should be put in first, and then the subsoil, which is usually harder and poorer in available plant food. It is important to make the soil firm and compact, as it is put in, by trampling or pressing.

Seventh: It is sometimes well to shade a plant for a few days from the hot sunshine, or to protect the roots by a mulch of straw or leaves, as well as of loose earth.

Transplanting Crops. — There are a number of crops which are grown almost entirely from transplanted plants. Nearly all orchard fruits and most berries are so grown. Tobacco is the only field crop which is so raised. Some vegetables, such as tomato, cabbage, and sweet potato, are raised in seed beds and transplanted.

To transplant crop plants, the farmer usually selects what is called a 'season' — that is, damp, rainy weather when the ground and air are full of moisture. In such weather, transplanted plants are apt to live. In dry weather, they may starve for lack of water before their root systems get re-established, especially if the soil is loose and porous. If, however, the soil is too wet, air is excluded, the soil is apt to 'bake,' and the plants do not thrive.

EXPERIMENTS

1. Transplant a tomato, a pansy, and other plants, following carefully the foregoing suggestions.
2. Transplant similar plants, disregarding in each case one or more of these suggestions. Compare the results and explain the causes.

PLANT REPRODUCTION FROM SEEDS

Budded Plants and Seedlings. — A plant grown from a bud is, as you have learned, a new plant produced from an old one. A seedling, or plant grown from a seed, is usually made up of parts of two plants. The pistil of the one receives pollen from the other. From the seed thus formed, a new plant is produced. There is, of course, less room for variation in a budded plant than in a seedling, which may have the qualities of one or both of its parents or even of more distant ancestors.

Most of our crop plants are grown from seeds. Since plants are apt to resemble those from which the seed was taken, the matter of seed selection is important.

Good Seed. — For good crops there are necessary three things, — good soil, good seed, and good tillage. Of the three, good seed is easiest to secure, and yet it is the one oftenest neglected. Thousands of dollars are lost by farmers every year through the use of inferior seed. Thousands of dollars are paid every year for those which could easily be grown at home.

Selecting Seed in the Field. — The farmer should select the best seed from the best plants. To do this he must make the selection in the field. He must consider each plant as a whole, selecting those that are healthy and productive.

Qualities to Consider. — If he gets his seed corn from the crib, he can, it is true, choose large, sound, well-formed ears. But these may have been the only ears on the stalks on which they grew. They will tend to produce one-eared stalks. The crop from them will be smaller than that from field-selected seed, chosen from stalks that have each two or more good ears. It costs little more in tillage and labor to raise forty bushels of corn on an acre of land than to raise twenty bushels; it costs nearly twice as much to produce forty bushels on two acres as it does to produce it on one acre.

Seeds may be selected from plants with a view to certain qualities or products. We prefer sweet, well-flavored melons, and choose them even when they are smaller and less productive than large, coarse ones. By careful selection of roots which are richest in sugar, the sugar in a crop of beets has been increased from eight to eighteen per cent.

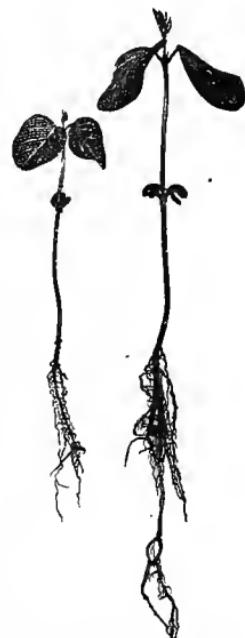
Some varieties are especially valuable because they are vigorous and able to resist disease. In certain sections, only wilt-proof varieties of cotton and of cowpeas can be grown. Farmers sow rust-proof oats because they make a crop in localities where varieties not resistant are entire failures.

Earliness of maturity is another quality which it is often desirable to cultivate, especially in fruit and vegetables. An extra early tomato or peach is more profitable as a market crop than one which ripens a week or ten days later.

Seeds, then, should be selected from healthy, productive plants having the desired qualities. They should be dried carefully, stored in a dry place, and protected against extremes of cold and heat.

Cleaning Seeds. — Seeds are cleaned by fanning or sifting them to remove chaff, dirt, weed seeds, and all small and immature seeds. From large, vigorous seeds a larger yield of more vigorous plants is secured. Seeds, especially purchased ones, should be examined for *pū'ri ty* and tested for *vi tă'l'i ty* before planting in the field.

Purity. — Purity means that they are seeds of the desired kind, free from dirt, weed seed, and chaff. Seeds very different in kind can be readily separated. It is easy to distinguish beans from wheat, or black peas from white ones. It is difficult to distinguish seeds that resemble those with which they are mixed, as chess, or cheat, and oats, — or very small ones, as some weed and grass seeds.

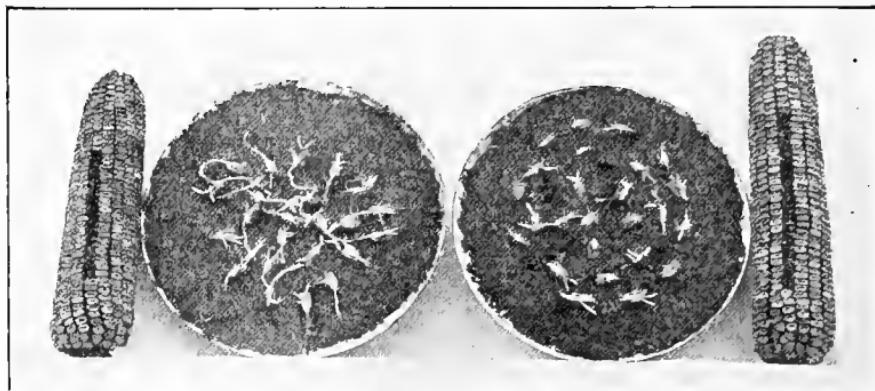


The plant on the left is from a light seed; that on the right is from a heavy seed.

Vitality. — Vitality is the ability of a seed to sprout and produce growth. There are many things which affect vitality. Age is one. The seeds of most agricultural plants will not germinate after they are a few years old. Seeds that are gathered before they are ripe have low germinating power. Those that are stored in a

damp place or that are exposed to great heat often have the germ injured or killed.

Seed Plots. — All seeds for planting should be carefully selected, examined for purity, tested for vitality, and planted where they



EARS OF CORN SELECTED FROM THE YIELD OF THE SAME EAR

The per cent of germination from the ear on the left is 100; from that on the right, 50.

This shows the importance of testing seed corn for vitality before planting.

will not mix with other varieties. For a garden crop or for one planted in small quantities, this is all that is necessary.

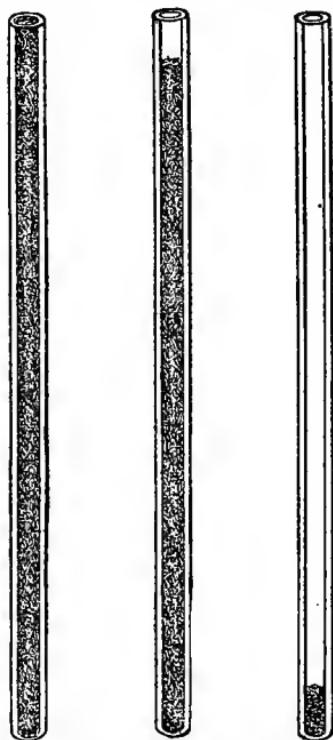
For a field crop where a large quantity is required, it is usually best to have a seed plot. This plot, so placed as to avoid mixing with the field crop, is planted with choice seed and given most careful cultivation. From its best plants, seed is selected for next year's seed plot, and the remainder is used for field planting. The farmer who thus selects and raises his seed does not complain of its 'running out.' Instead, his varieties improve year by year, and the increase in quantity and quality of crop-yield repay his care a hundred times.

Purchasing Seed. — It is usually desirable to purchase seeds, such as clover and grasses, which need special machinery to clean them and free them from chaff and hulls.

Plants that thrive in a certain soil or climate sometimes lose desirable qualities under different conditions. Certain varieties of tobacco are grown in the United States from Cuban seed. If home-grown seed be used even one year, the flavor and texture of the leaf are changed. It is sometimes desirable to buy seed in order to influence the ripening season of a crop. In a warm climate seed from the north mature earlier than home-grown seed of the same variety. Some Texas farmers buy cotton seed from North Carolina in order to have their crop ripen early before the Mexican boll weevil becomes most injurious.

Losses by Impure Seeds.—In purchasing seeds it is always economical to get high-grade, well-cleaned ones from a reliable dealer. Suppose a farmer buys at less cost an inferior grade. Sometimes half or more of such seed consists of impurities. The farmer's loss is threefold. He loses the money which he paid out. He loses the time, labor, and money spent in cultivating his field. He loses the profit which he might have gained. Moreover, he may have brought in weed pests.

Home-grown Seed.—As a rule, it is to the farmer's interest to grow his own seeds. He is thus saved much unnecessary expense. He knows the kind, quality, and age of his seed. He

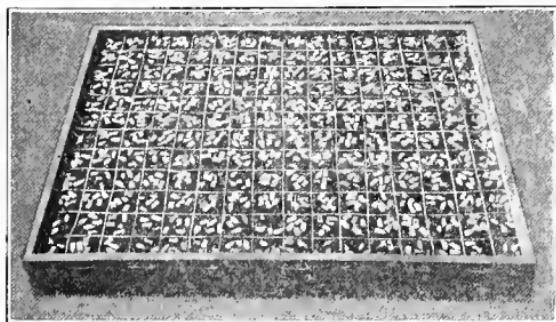


The tube on the left shows one pound of Kentucky blue grass seed, as bought; the middle tube shows the amount of dirt, weed seeds, and broken seeds; the tube on the right shows the good seed.

avoids the risk of introducing new weed pests. He gets acclimated seed, which is in many cases an advantage. By carefully selecting seed from the best plants, he can grade up and improve a variety.

Planting.—*Depth.*—As you know, seeds differ much in size. This naturally makes a difference in the depth that they should

be planted. Each seed contains a store of food to nourish the germ under ordinary conditions until it can send forth its root and stem and begin growth. If the seed be planted too deep, this store is used up before the plant is



A CONVENIENT SEED-TESTER

It consists of a shallow box, filled with soil. It is divided into sections by a wire netting with one-inch meshes.

well established. Sometimes the deep-planted seed cannot get air and warmth enough to enable it to germinate at all.

Some seeds, such as wheat, come up with thin blades and slender leaves. These can make their way through the soil more easily than thick-leaved plants, such as beans, and so may be planted deeper.

Soil Conditions.—Seeds require for germination a certain amount of moisture, heat, and air. They grow best when the soil around them is made fine and compact, not so close as to exclude air, but close enough for the soil particles to touch them and supply moisture. Gardeners often press small seed down with a board and trample the beds in which larger ones are planted, and farmers roll the land on which grain or grass seed are sown. They know that firmly-planted seed come up in a shorter time and produce stronger plants than those put in loose soil.

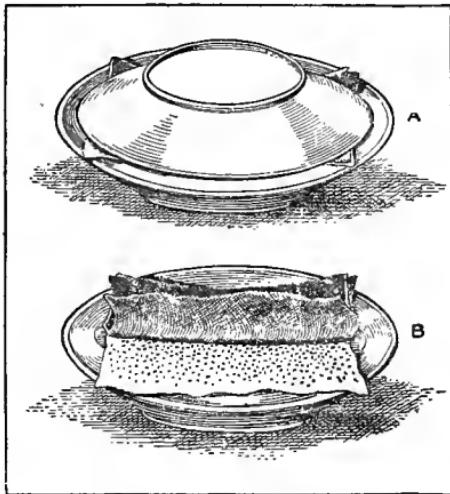
Time of Planting. — Seeds vary greatly in the amount of warmth that they require for germination; this requirement determines the time of planting. Cotton, for instance, requires much heat, and oats need little; so cotton is planted late in spring when the soil is warm, and oats early in spring or in fall when it is cool. Plants of the same family vary greatly in this respect. Corn and wheat both belong to the great cereal family. Corn requires much warmth; wheat takes so little that it has been known to germinate on ice.

EXPERIMENTS

1. Save seed from your largest and from your smallest pansies and plant some of each in garden mold and in poor soil. Note the resulting differences.

2. Examine a handful of wheat for impurities.

3. Make a seed-tester. To do this, dip two pieces of flannel in boiling water in order to destroy mold. Lay one piece in a plate and put on it one hundred seeds, such as clover. Put over them the other piece of flannel and cover with another plate. Add water when necessary so as to keep the flannel moist, and keep the seed-tester at a temperature of 70° to 80° . The seed will germinate in a few days. The number which germinate shows the per cent of vitality. Two pieces of wet blotting paper may be used for a seed-tester. The seed is placed between the two, and they are kept damp. Several layers of these can be kept in a shallow wooden box.



A SMALL SEED-TESTER
A, closed; B, open.

4. Fasten two panes of glass together by a wooden frame, as illustrated. Fill the box thus made with fertile soil. As you put in the soil, plant corn and beans close to the glass, at depths of four, three, and two inches, one inch, half an inch, and a quarter of an inch. Cover the glass with dark paper and keep in a warm place. Remove the paper every day and

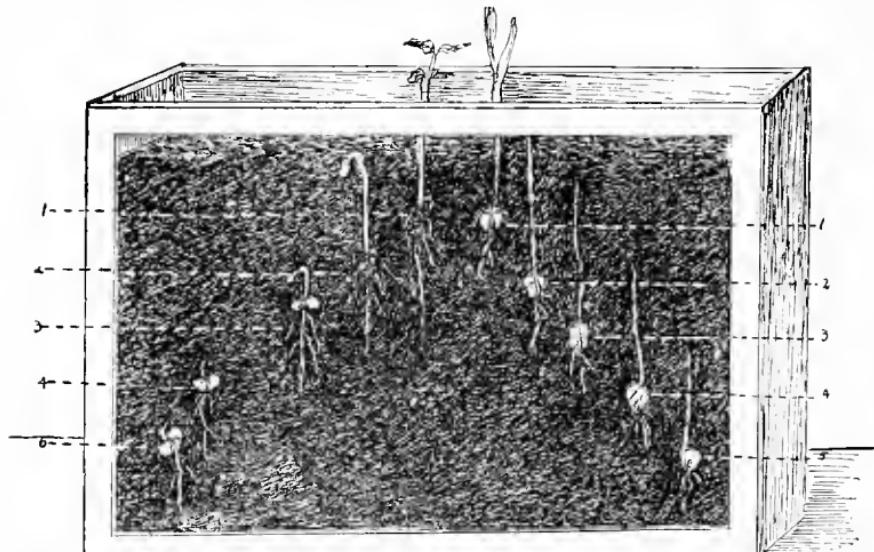


ILLUSTRATION OF EXPERIMENT 4

examine the seeds. What difference is there in the germination of seeds at different depths? Which plants make their way to the surface from the greater depth, corn or beans, and why?

5. Plant twenty-five morning-glory seeds in a box of fine soil and press them down firmly with a board. Plant twenty-five seeds in a box of rough soil and leave it loose. What difference is in the number and appearance of plants in the two boxes?

6. Weigh one hundred seeds of several different kinds, such as peas, clover, and corn. Put them in water and weigh again in twenty-four and in forty-eight hours. What difference is there in weight? What does this prove as to the moisture required in the germination of different kinds of seed?

PLANT IMPROVEMENT

Origin of Cultivated Plants.—Our cultivated plants, as you probably know, originated from wild ones. These kindred of our field crops exist still in many parts of the world, and it is interesting to compare the two. In appearance and in habits of growth, the wild and the cultivated plants differ as much as do savage and civilized races of men. For instance, the ancestor of most of our apple trees is a European crab. It is small and poorly flavored, very unlike the large and luscious fruits familiar to us. Hundreds of varieties differing in habit of growth, and in the size, color, flavor, and ripening season of their fruit have been developed from that insignificant-looking, ill-flavored crab.

How have these wonderful changes been made? It has been done by years and centuries of care and cultivation, raising plants from the best specimens under the most favorable conditions.

The Law of Heredity.—Changes in varieties are made by taking advantage of certain laws which govern all living things, both plants and animals. The first is the law of heredity, that 'like begets like.' Corn produces seed which brings forth corn, never by any chance wheat or rye. The product shares the general, and, to a great extent, the special characteristics of the parent plant. If that ripened early, so will this; if that was sugar corn, this will be sweet.

The Law of Variation.—You will notice that we say that a plant inherits 'to a great extent' the special characteristics of its parents. It is just here that another law comes in, a law which makes progress possible. This is the law of variation, the tendency of offspring to be unlike the parents. If the plant were in all respects exactly like its parents, no improvement would be possible. Usually variations are not great, for the law of heredity is very strong.

Selection. — Suppose that in a field of beans you find four plants bearing beans a little different from the remainder. One plant bears beans that mature a day or two earlier; the second has pods a little larger than the others; the third has better-flavored beans; the fourth has more pods than the others. Suppose you save seed from these plants and keep and cultivate them in four plots. The second year you again select seed, choosing from the first the earliest beans, from the second the largest, from the third the best-flavored, and from the fourth the one bearing most pods. If you do this year after year, you will have four distinct varieties. By reasonable care you can keep them distinct, thanks to the strength of the law of heredity.

Effect of Cultivation. — Suppose that in each case half your seed is planted on fertile, well-tilled soil and that the other half is planted on poor, badly-cultivated soil. You will find that on the fertile soil the improvement is great and the variations decided. On poor soil, the plants will have to use most of their energies to live and grow, and have little left for improvement or variation.

Three Methods of Improvement. — What you learn from this experiment is what others before you learned by observation and experience and applied to the improvement of plants. The three chief ways in which plants are improved are by seed or bud selection, by cultivation, and by crossing and hybridizing. Crossing and hy'brid iz ing give us new varieties and even new species. A cross is a plant obtained by fertilizing one variety with pollen from a different variety, as one kind of pear with another. A hy'brid is the offspring of two plants of different kinds, — as a blackberry and a raspberry.

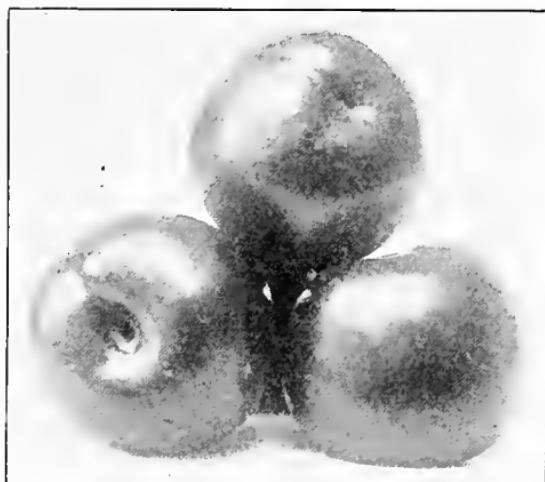
Plant Breeders. — Plant breeders, by selection and reselection of seeds, grafts, and cuttings, and by crossing and hybridizing

new and old varieties, improve varieties of fruit, vegetables, and flowers, and create new ones.

One of the most famous plant breeders of the present day is Mr. Luther Burbank, who lives in California. He has produced new species, among others the plūm'cot, a union of the plum and the apricot, and the pri'mus berry, a union of the raspberry and the blackberry, having the general appearance and combined flavors of both.

Keeping up a Variety.—It is not enough to originate a good variety. It must be kept good by care and attention. All improved varieties tend to deteriorate, or grow worse. They are artificial products, and the tendency is to return to the state of nature. Scientists say they 'revert to type,' or go back to the characteristics of their wild ancestors. Farmers say the 'seed runs out.' In different terms, scientists and farmers express the same truth.

Plant improvement can easily be maintained and increased. First: Seeds or buds should be selected from plants having the qualities it is desired to maintain. Second: Good varieties should be protected against mixing with inferior ones. Third: They should be given such care and cultivation as suit them best. Plants can, to some extent, adapt themselves to unfavorable conditions of soil,



From photograph furnished by Mr. Burbank

PLUMCOTS

moisture, and climate, but their most flourishing and most profitable growth is under favorable conditions.

This work of plant improvement is one in which every man and child on a farm should take part. By selecting buds and seeds from the best specimens, a farmer should try to increase the yield and improve the good qualities of every crop which he raises. Every child can make interesting experiments which may result in the development of new and valuable plants.

EXPERIMENTS

1. Save seeds from balsams, or touch-me-nots, selecting and keeping separate the seeds of plants bearing the most and the least double blossoms. If this process of selection be continued two or three years, what is the result?
2. Compare the wild onion with its relative, the garden onion. What changes have been made by cultivation?
3. Experiment with the cross breeding of corn. Use two good plants. Keep the ears of one covered with paper bags until you are ready to pollinate them. Then dust them with the tassel from another good plant, and re-cover with the paper bags for a few days.
4. Decide on some change that you think will improve a certain plant, and try to make it by seed selection and cross breeding. Remember that these changes must be in line with the natural development of the plant.

OUTLINE OF CHAPTER THREE

SOIL IMPROVEMENT

General:

Nature's processes and man's

Drainage:

Benefits:

Gives plants more room

Makes soil warmer

Favors processes which produce plant food

Makes soil workable earlier

Prevents washing

Methods:

Plowing

Surface ditches

Underdrains

Terraces

Irrigation:

Methods

Advantages

Tillage:

Benefits:

Breaks and makes fine the soil

Regulates soil moisture

Admits air and heat to soil

Destroys weeds

Tools used

In preparing land:

Plow, harrow, roller, etc.

In cultivating crop:

Harrow, cultivator, sweep, hoe, weeders, etc.

In harvesting crop:
Reaper, mower, etc.

Methods:

Flat, ridge, or hill

Deep, shallow

Crop Rotation:

Disadvantages of one-crop system

Advantages of proper rotation:

Money crop and feed for live stock are raised

Nitrogen-gathering crops prepare for nitrogen-destroying ones

Drain on land is lessened by crops of different habits of growth

Best use is made of manures and crop residues

Weeds, insect pests, and fungous diseases are kept in check

Land being occupied, plant food is not wasted

Labor of men and teams is as evenly distributed as possible

Green Manures; Legumes and Soil Inoculation:

General benefits of catch, or cover, crops

Special advantages of legumes

Stable Manure:

Benefits:

Supplies plant food

Makes food in soil available

Improves texture and moisture condition of soil

Warms the soil

Value depends on

Kind, age, and food of animals

Methods of saving and applying

Sources of loss:

Escape of liquid matter

Leaching and washing of rains

Escape of gases in fermentation, or 'heating'

Composting

Commercial Fertilizers:

Rules for use:

Depend mainly on tillage, crop rotation, and natural manures

Choose the commercial fertilizers best and cheapest for soil and crop

Nitrogen suppliers:

Guano, nitrate of soda, ammonia salts, cotton-seed meal, dried blood and tankage, fish scraps, artificial nitrates

Phosphoric acid suppliers:

Guano, bones, phosphate rock

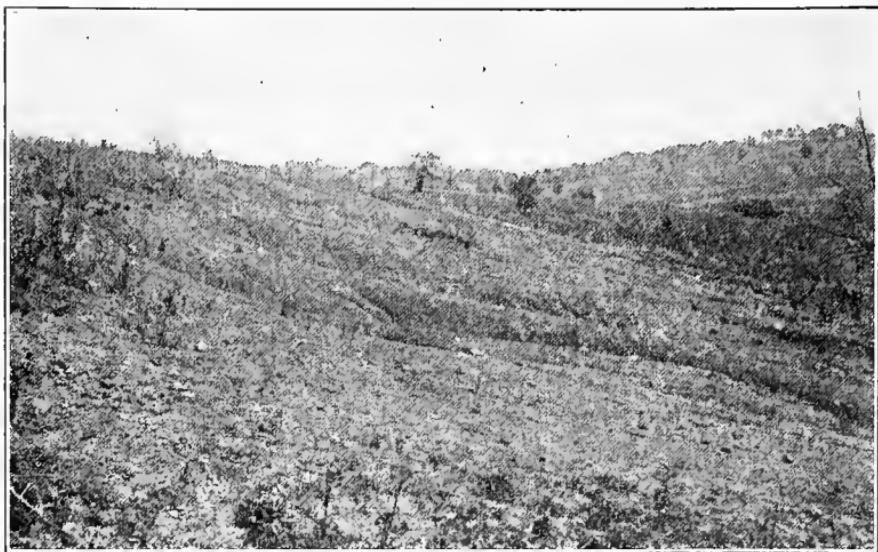
Potash suppliers:

Ashes, kainit, muriate and sulphate of potash

Calcium supplier:

Lime

Testing and mixing fertilizers



RESULTS OF BAD FARMING

This field shows the results of lack of rotation and of improper methods of cultivation.



RESULTS OF GOOD FARMING

This field, not far from the above, has been made and kept fertile by rotation of crops and proper methods of cultivation.

CHAPTER THREE

SOIL IMPROVEMENT

GENERAL

Past and Present Conditions. — The subject of soil improvement was little considered by American farmers in early days. Crop after crop of corn and wheat, cotton and tobacco, was raised; then fields were turned out to 'rest'; new fields were subjected to the same treatment.

"Why not?" thought the farmer, if he thought at all on the subject. He was master of uncleared forests and untilled valleys. It seemed no serious matter to exhaust the fertility, not merely of some fields, but of whole farms. To the west lay vast prairies, their deep soil unbroken by the plow. Foolish and extravagant, but natural, it was that the farmers should take the cream of this rich land.

But, you know, if we keep on taking off cream, after a while we have nothing left but skim milk. And from skim milk we cannot make butter. Thus it is with land. If we keep on taking off the cream of its fertility, after a while we have poor land, and poor land is worthless for crop raising.

Nor are farmers now able to move west and take up rich new farms in place of poor old ones. The country is settled, fertile lands are occupied, land values have increased. It has become necessary for the farmer to make the most and best of his farm. And it is not the number of acres which he owns, but their fertility, which brings him money and success and happiness.

Nature's Processes. — How is a soil made fertile? We have observed the processes of Nature. We have seen how they build up soil from rock. Left to themselves, they usually improve it and make it fertile. Frost fines and mellows it, rain brings plant food from the atmosphere, and chemical changes make available some elements in the soil. Roots drink in food from the surface and pump it up from the subsoil; decaying plants give to the soil the elements thus gathered and others derived from the air. Year after year the barren land improves; slowly but surely it becomes fertile.

Farm Methods. — But the farmer cannot wait on the slow processes of Nature, nor restore to the land all the fertility of its products. His business is to take from it once a year, or oftener, the richest of these products. Can he do this and not impoverish it? He can, if he will imitate and aid Nature. The plow can fine and mellow the soil more quickly than the frost; green and stable manures can improve texture and supply humus, and these manures and commercial fertilizers can add plant food more rapidly than do the methods of Nature.

The farmer can take the place of Nature's reclaiming processes and protect his land against her destroying ones. By drainage and irrigation and tillage he can largely regulate the supply of moisture, and improve the texture of the soil and its relations to heat and air. By proper rotation he can lessen the drain of cropping. To do all this, he must work and work intelligently.

The Ideal Soil. — The best soil for agricultural purposes is a loam containing sand, clay, humus, and lime. The sand admits air and water, the clay holds moisture and plant food, the humus absorbs and retains moisture, and the lime assists the decay of vegetable matter. This soil is ideal if it be rich in available plant food and has a well-drained subsoil. Most farm soils have not this

nature; when they have, they do not retain it unless they are properly cultivated.

Improving Soils. — The farmer cannot change the character of a soil, but he can modify and improve it. There are three ways in which soils need to be cared for and improved.

Texture. — First: The texture should be attended to, so as to give plants the best possible conditions with regard to moisture, air, and heat. This is done by proper tillage and by applications of manures which supply humus. Humus is lacking in most of the 'run down' farms of the East; it is abundant in the fertile prairie lands of the West. Lime, too, often benefits the texture and condition of land.

Plant Food. — Second: There should be supplied the plant food which is naturally lacking, or which is taken out by crops. You know that there are three elements that sometimes need to be supplied, and that they must be in forms which plants can use. Nitrogen is used chiefly in the form of nitrates; phosphorus, of phosphoric acid; and potassium, of potash: all three are compounds formed with oxygen.

All crops do not remove elements in the same amounts or the same proportions. Forage crops, for instance, of which the stems and leaves are used, need much nitrogen to form their luxuriant foliage; grain crops store up much phosphorus in their seeds. Legumes are sometimes called 'lime plants' because they use so much calcium, which is usually applied to the soil in the form of lime. Whatever is taken from the land must have its place supplied, or the land grows poor.

Conditions for Bacteria. — Third: Conditions should be made favorable for nitrogen-gathering bacteria. You have already learned that these tiny creatures in the soil change nitrogen into compounds which plants can use. These bacteria will not work

unless they have food, warmth, air, and moisture, and are protected from strong light. In poorly-drained soils, there thrive harmful bacteria which consume nitrogen and make the soil acid and unfit for plant life.

Common sense — and it is nowhere more important to listen to its voice than on the farm — will tell you that as soils differ in character, they need different treatment. Each kind has its special natural defects and adaptations, of which you have already learned something.



Clay



Loam



Sand

THE TEXTURE AND RELATIVE SIZES OF SOIL GRAINS

Improving Sandy Soils. — On account of the size of its particles, a coarse, sandy soil has little power to hold moisture and plant food. Elements needed by plants are often dissolved by rain water and leached or washed out. In dry weather, its crops suffer for moisture.

What can a farmer do to improve a sandy soil? If it be not too dry and coarse, he can make it very productive, for it responds quickly to good tillage and fertilizing. It needs to be kept compact by rolling and other methods of cultivation. It needs to have its soil spaces filled with humus so as to enable it to hold food and moisture: this is best done by applying green manures and well-rotted stable manure. It needs to have its losses of plant food supplied by application of manures and commercial fertilizers.

Improving Clay Soils. — In a clay soil the texture is often too close. Water runs off its surface, and plant food and moisture are

not readily available in it. Its crops suffer from both wet and dry weather,—from wet because water stands on it and drowns the plants, from dry because water does not rise freely in it and because it becomes so hard that roots cannot penetrate it.

How can its faults be corrected? If it be low, it needs to be drained to remove surplus water. Then it needs to be made more open and porous by applications of lime, green manures, and coarse stable manure. It is especially important for clay soils to be worked when in proper condition, for they are injured by tillage when too wet or too dry. They are improved by being 'put down' in grass, both to avoid tillage and to increase their store of plant food. Clay soils retain manures and fertilizers better than do sandy ones.

Improving Loams.—A loam, especially a limestone loam, is naturally a good farm soil. It can be kept so by proper tillage and by returning to it the humus and plant food removed by cropping.

Reclaiming Alkali and Swamp Lands.—On alkali lands, as you have learned, there are deposits of mineral salts. These salts are brought to the surface by capillary attraction, and the rainfall is not sufficient to drain them off. Such soils need irrigation, drainage, and deep plowing to free them from these salts.

Swamp soils are generally of good texture and rich in plant food; if relieved of surplus water, they are very productive.

EXERCISE

1. In the exercises under Drainage, Irrigation, Tillage, Crop Rotation, Green Manures, Stable Manures, and Commercial Fertilizers, there are suggested experiments which show methods of improving soils.



Clay soil plowed when too dry; it is hard and cloddy.

2. Observe the methods used on farms in your locality. Compare the methods used by successful and unsuccessful farmers.

3. Put a layer of salt about one fourth of an inch thick in the bottom of a pan and cover it with wet sand to the depth of two or three inches. Set the pan in the sun till the sand is dry. What do you find on the surface? Put the top layer of sand in a glass of water; let it settle, and taste the water. Put similar layers of salt and sand in a pan having a bottom of wire gauze over which is put a cloth. Pour water on this frequently and allow it to drain off. Then dry the sand and compare with the other. What do these experiments show as to the formation and reclamation of alkali lands?

DRAINAGE

Reclaiming Land by Drainage. — Nothing is of more importance to a crop than the regulation of soil moisture. If there be too little, the plants perish for want of water; if too much, they starve for lack of air to the roots. In low sections and in regions of heavy rainfall, one of the chief problems is how to dispose of surplus moisture. It is often necessary to drain these lands,—that is, to carry off the water by drains or ditches.

Holland is a striking instance of the extensive and profitable use of drainage. By dikes and ditches, thousands of acres have been reclaimed from the sea. Their products every year are worth millions of dollars. Our government has spent over ten million dollars in dikes and jetties, to drain and protect the lower Mississippi Valley.

Farm Drainage. — Farm drainage, which we are now considering, deals chiefly with the removal of free, or standing, water from wet fields. In the eastern part of the United States, there are over a hundred thousand square miles which need drainage. These swamp and bottom lands are well supplied with plant food,

and need only to have the surplus water removed to make them very productive.

Benefits of Drainage. — Let us consider some of the ways in which drainage benefits soils and crops.

First: Drainage gives plant roots more room. The roots of few agricultural plants can penetrate airless, water-filled soil. As water is drawn off, air is admitted. The plants are not drowned by standing water in wet weather; in dry weather they have the advantage of larger areas from which to collect food and water.

Second: Drainage makes the soil warmer. In wet soils a large part of the heat waves are used to convert the surplus water into vapor. On these cool, wet lands, plants grow slowly. Drainage lessens evaporation by drawing off the surplus water; it also warms the soil by admitting air.

Third: Drainage, by warming the soil and admitting air, favors processes which produce plant food. As you learned, bacteria which prepare nitrogen for plant use work best in warm, rich, moist, well-drained soils. In wet, ill-drained land, bacteria thrive which destroy nitrogen and form acids injurious to crops.

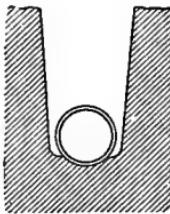
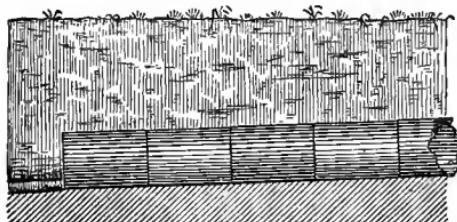
Fourth: Drainage, by drying the soil, makes it workable earlier in the spring. Crops can be planted earlier, and thus get the benefit of a longer, and usually of a more favorable, growing season.

Fifth: Drainage prevents washing on light and rolling land. The particles of such soils do not adhere closely, and heavy rains carry away the plant food and even the soil itself. Have you not seen thin, unproductive hillsides scarred with gullies? Fringing these hills is often a rank growth of weeds and briars, which shows where their fertility has gone.

Methods of Drainage. — Sandy and light soils are naturally drained, unless the water table is near the surface. Clay soils and those with clay subsoil often need artificial drainage.

Plowing.—Wet land may be drained to some extent by deep plowing. It should be thrown up in narrow 'lands,' or ridges, from

twenty to sixty feet wide. The 'dead' or finishing furrows should be connected by cross furrows running so as to carry off the water.

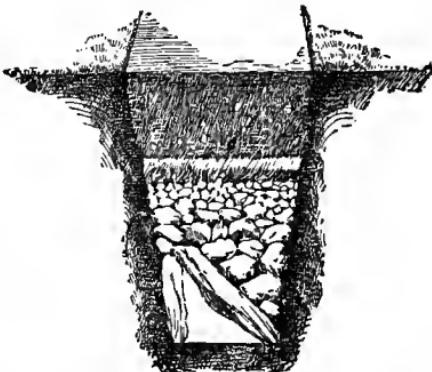


On the left is a tile drain in place; on the right is a section not yet covered.

Ditches and Underdrains.—Where there is too much water to be disposed of by deep plowing and water furrows, surface ditches or underdrains should be used. All drains should be large enough to carry off the surplus water and should lead gradually to the lowest part of the field.

Open ditches are cheaper, but less satisfactory, than underdrains. They carry off in the water much plant food and fine particles of fertile soil, and they interfere with the cultivation of land. Where it is necessary to use them, they should be broad, with sloping sides, so that the farmer can cross them with his team.

The best underdrains are tiles, tubes made of clay. They are out of reach of the plow, do not fill up like surface ditches, and take off surplus water, without carrying off fine particles of soil. Good substitutes for tile drains



An underdrain made with stones covered with earth

are made by digging ditches as deep as needed, putting in a layer of loose stones or brush, and then filling them with earth.



LAND TERRACED TO PREVENT SOIL WASHING

Hillside Ditches and Terraces.

—Sandy, rolling land which does not suffer from standing water often needs to be protected against washing rains. It should be terraced so as to break long, downward slopes, or ditched with broad, shallow ditches which lead gradually to the lower ground.

Hillside land should be plowed deep, and cultivating tools should run as near on a level as possible. It is often a good plan to put thin hillsides down in grass or to leave them



Soil washing caused by harrowing up and down a hill, instead of around it

for woodland. The roots bind the soil together and prevent washing.

As a rule, shallow plowed land washes most, unplowed land less, and deep plowed land least of all.

EXERCISE

1. Take two thrifty plants of the same kind and as near the same size as you can get. Set one in a glass jar filled with moist, mellow soil; set the other in a flowerpot of similar soil, with a layer of gravel at the bottom. Water equally and observe the results on growth. In three or four weeks soak the soil away, and examine the root development of each plant.
2. Grow timothy and alfalfa in flowerpots. Set these pots in pails of water deep enough to cover their tops. Which plant suffers more from lack of drainage?

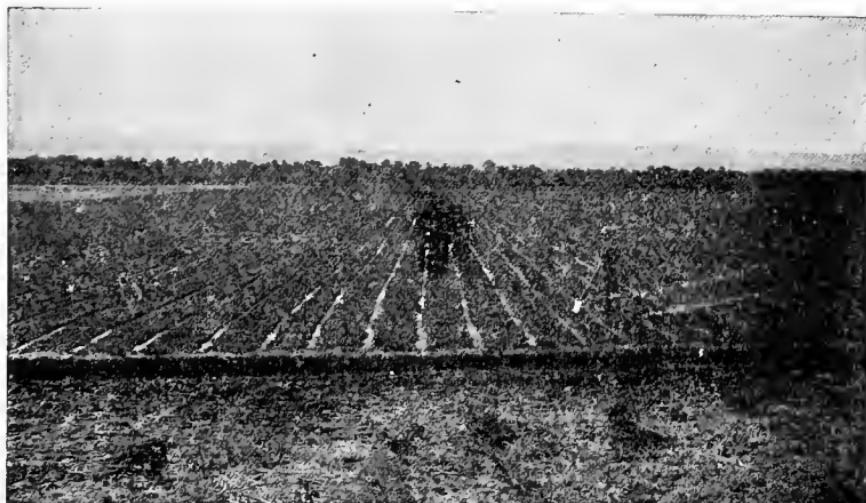
IRRIGATION

Arid and Semi-arid Region. — A soil may contain abundant plant food but be unproductive because moisture is lacking. This is the case in the arid and semi-arid region of the United States, which lies between the ninety-fifth meridian and the Rocky Mountains, and extends from Canada almost to the Gulf of Mexico. It includes all or part of the states of Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Texas, Washington, and Wyoming, — a vast region of three hundred million acres of land. The ocean breezes are deprived of moisture by the mountains and plains to the east and west, and come dry and parched to this Great Basin.

Uneven Rainfall. — Where the rainfall is abundant or excessive, it may be so uneven as to allow the crops to suffer for moisture. In parts of Florida where the yearly rainfall is sixty or seventy

inches, crops often suffer for lack of rain during the growing season. Droughts are becoming more frequent and prolonged in many of the eastern states on account of the destruction of the forests, which are Nature's reservoirs of moisture.

Irrigation. — Crops are protected against scanty or uneven rainfall by irrigation. Irrigation is a system of distribution of water



IRRIGATING ALFALFA BY THE FURROW SYSTEM

On this western field, alfalfa is irrigated after each cutting; there are sometimes as many as six cuttings a year.

to crops, by means of canals and reservoirs connected with streams or lakes. Irrigation is not a modern invention. It was practiced in Egypt and in India thousands of years ago. When the Spaniards first came to America, they found Mexico and Peru irrigated by vast systems of canals.

Our government is spending millions of dollars in irrigating the arid states. Much of this land was once a barren waste dotted with stunted sagebrush and cacti, the home of prairie dogs and

rattlesnakes. Where the life-giving water has been distributed, it is now fair with farmhouses, pleasant gardens, and fertile fields.

Arid Soils. — The irrigated land of the arid states is very valuable for agricultural purposes. It is a light, sandy, or silty, loam, which absorbs water freely, parts with it slowly by evaporation, yet yields it regularly and freely to plants. Instead of changing, as most soils do, at a depth of a few inches to a subsoil of different character, it is almost the same for twenty or thirty feet. The soils in humid regions dry hard, with a surface crust; these arid soils dry loose, forming a natural soil-mulch.

The weather is a great and usually an uncertain factor in crop production. In irrigated arid lands, this is not the case. The farmer turns on the water when his crop needs it, and the plants are sure to get the moisture they need, no more, no less. As there is no danger of rain during harvest season, grain is often allowed to ripen on the stalk; it is harvested by a combined steam harvester and thresher, and carried from the fields in bags, ready for the mill.

EXERCISE

1. Fill a shallow box with dry soil. Bore a hole on one side near the center. Make a trench across the middle of the soil and pour water

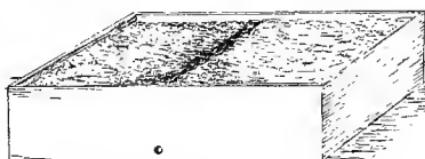


ILLUSTRATION OF EXPERIMENT I

slowly in till it runs out at the hole. Remove the soil next to the trench and see how moisture has spread by capillary action. This is the principle upon which irrigation is based.

2. Do you know of any land that usually or often suffers from lack of water? Do you think it could be irrigated profitably? Give reasons for your opinion.

TILLAGE

Crop Increase by Tillage. — On a certain farm the average yield of wheat was sixteen bushels to the acre. This did not satisfy the farmer. He was tilling his fields as well as his neighbors, but he began to till them better. By thorough and proper cultivation, unaided by manures or fertilizers, his farm was made to produce thirty-four bushels of wheat to the acre instead of sixteen. How did tillage more than double the crop yield? To understand this, we must consider the purposes and results of tillage.

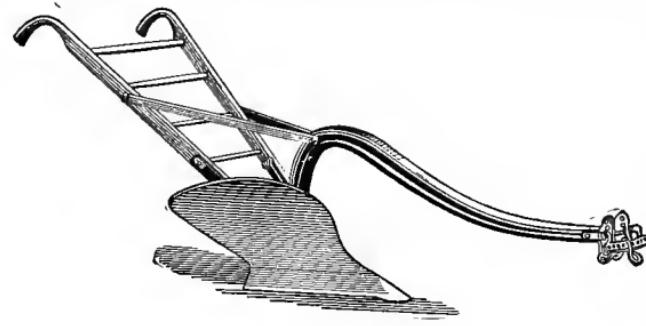
Benefits of Tillage. — First: Tillage breaks and makes fine the soil, thus opening it to plant roots. At first there is no close connection between soil and plant. Until it can connect itself with the soil, the young plant lives on the food stored in its seed or in its stem. If its tender young roots come in contact with clods and hard soil, their progress is checked or delayed. They have such a narrow area from which to collect food and water that the plant grows slowly or dies of starvation. But if the soil be fine, deep, and well-drained, the roots range freely to collect food and moisture, and the plant grows strong and thrifty. The finer the soil, if not too compact, the larger is the feeding-ground and water-range of the plant.

Second: Tillage regulates the soil moisture. Rain, falling on a loose, broken surface, sinks in instead of running off. In fine, deeply-broken soil, water is held as in a sponge. This deep tillage should be followed by shallow tillage. As before explained, a loose, dry soil-mulch on the surface prevents the escape of moisture by capillarity and evaporation. A well-tilled soil also absorbs more moisture from the air than a hard or rough one.

Third: Tillage admits air and heat to the soil. You have learned

how necessary air is to the roots of plants, and to the processes that form plant food from the elements in the soil. Tillage extends these processes to a greater depth and hastens the decay of organic matter.

Fourth: Tillage destroys weeds. Weeds are stronger and more vigorous than most agricultural plants; they should be destroyed while young to keep them from depriving the crops of food, water, and sunlight.



A GOOD PLOW

The Plow. — The plow is the first and the most important implement of the farmer. It cuts, inverts, and roughly pulverizes the soil.

It opens the land to frost, sunlight, air, and moisture and prepares it for the crops.

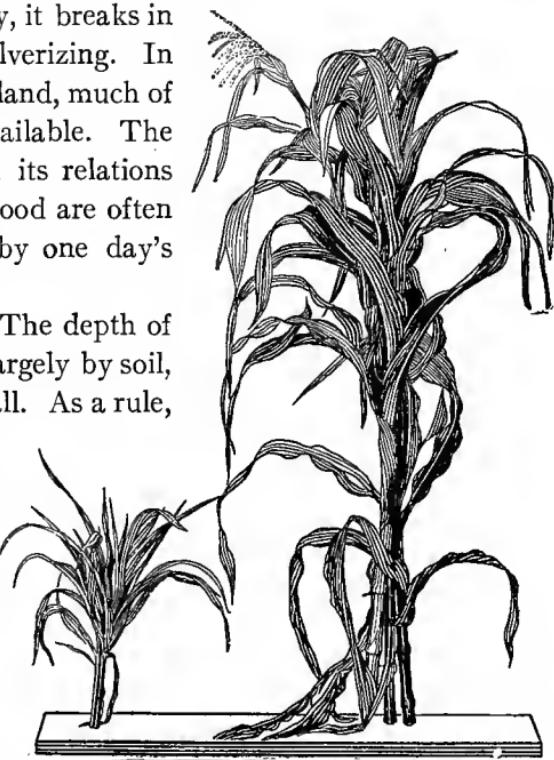
Time to Plow. — The best time to break up land with the plow depends on soil, climate, and crops. As a rule, it is well to plow clay soil in fall or winter, especially in cold climates where the land freezes and does not wash. The texture is improved by it, and there are destroyed many harmful insects which winter in the soil. Fall plowing also lessens the burden and rush of spring work. In warm climates and on light soils, fall plowed land needs to be protected against washing, leaching rains, by a cover crop of grain or clover.

Fall or winter plowed land should be cultivated as early as possible in the spring. This prevents loss by evaporation of the winter store of moisture, and enables the crop to get the benefit

of it. If this moisture be allowed to escape before a crop is planted, the crop is apt to suffer in summer, especially on light, upland soils.

Condition of Soil. — At whatever season plowing is done, the soil should be in good condition, neither too wet nor too dry. When in condition for plowing, the furrow-slice breaks and roughly pulverizes the soil. If too wet, soil, especially clay, 'bakes,' or dries hard; if too dry, it breaks in large clods instead of pulverizing. In either baked or cloddy land, much of the plant food is unavailable. The texture of the soil and its relations to moisture and plant food are often influenced for months by one day's plowing.

Depth of Plowing. — The depth of plowing is determined largely by soil, season, crop, and rainfall. As a rule, fall and summer plowing should be deep, and spring plowing shallow. Land in a region of scanty rainfall needs shallow cultivation. So does thin soil until it can be improved and deepened. Usually, however, shallow cultivation means poor land, poor crop, and poor farmer. On deep-plowed land, crops flourish in dry weather because they are stronger and have deeper root range; they flourish in wet weather because drainage is better.



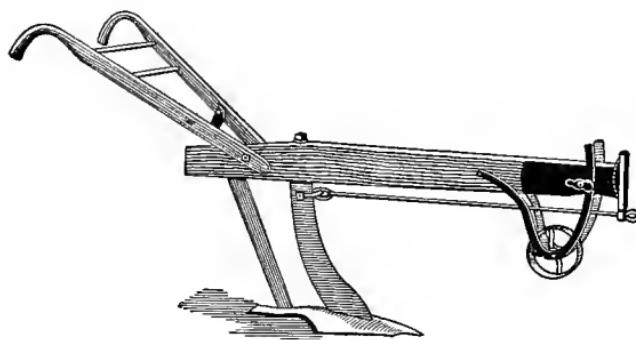
The plant on the left was grown in subsoil; the plant on the right, in soil from the same field.

As we learned, depth of plowing and direction of furrow do much to drain land and also to prevent washing.

Some farmers work as if only four inches of the top soil belonged to them and they were afraid of robbing some one below. If they would cultivate the soil well to a depth of eight inches, it would produce much larger crops at little more expense.

A shallow soil should be deepened gradually, an inch at a time, until its depth is nine or ten inches. It is important that the process be gradual; productiveness is lessened by bringing to the surface a large amount of the subsoil, because the plant food in it is unavailable.

It is generally a bad plan to plow land the same depth year after year. The plow, as it lifts the furrow-slice, presses the soil together at the bottom of the furrow. In land plowed the same depth for several years, a hard, close layer is formed, called the 'plow pan.' This is injurious in most soils. The surface soil is apt to wash off, and the hard lower soil does not freely admit roots and moisture.



A GOOD SUBSOIL PLOW

Subsoiling. —

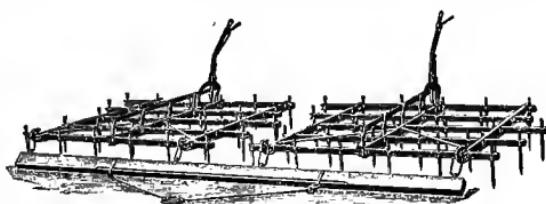
The subsoil plow is one which loosens the lower soil and, without bringing it to the surface, opens it to air, moisture, and roots. Some good farmers approve and practice subsoiling.

Others say that few soils require or repay the labor. They think that it is better to loosen the lower soil by deep plowing with large plows drawn by heavy teams, by under-drains, and by clover and root crops.



PLOWING

The Harrow. — In the preparation of land for a crop, the plow is usually followed by the harrow or drag. The chief office of the harrow is to pulverize finely the surface soil. It secures a fine, even surface free from clods, prepares a shallow seed bed, covers seeds, and destroys weeds.



A GOOD HARROW

The Roller. — On land which has been seeded in grain or grass, the roller often follows the plow and the harrow. Farmers claim



A GOOD ROLLER

that its use gives a better stand and larger yield. Rolling compacts the soil. It makes the soil-spaces smaller, and causes water to rise by capillarity. Thus seeds are better supplied with moisture; they germinate more quickly, and form stronger plants.

Sometimes, to avoid leaving the surface too compact, the roller is followed after a time by the harrow to admit air and to form a soil-mulch.

Purposes of Crop Cultivation. — After the soil is prepared with plow, harrow, and roller, and the crop is planted, cultivation is continued with harrow, hoe, and other tools. Why do we cultivate the growing crops?



On the left the soil is compacted by rolling; on the right the roller has been followed by the harrow, to form a soil-mulch.

First: To keep a soil-mulch on the surface and to prevent, as far as possible, loss of soil water by evaporation.

Second: To admit air to nourish the plant roots and to prepare plant food.

Third: To destroy weeds in order to prevent their robbing the plants of food and water.

Deep and Shallow Cultivation. — The plowing and preparation of land should be deep and thorough. After the crop is planted, it is seldom wise to use deep cultivation. It dries the soil too far down and breaks plant roots. Flat, shallow cultivation is usually much better. The surface soil should be kept pulverized.

Flat and Ridge Cultivation. — Good farmers say that the best tools for crop cultivation are cultivators and weeders with small teeth that leave the surface smooth. This protects the land against loss of moisture by evaporation and against leaching, washing rains. On cold, wet soils, hill or ridge cultivation is of advantage. As more surface is exposed, evaporation is more rapid. The rows between the ridges also act as ditches to carry off surplus water.

Time. — Cultivation is most beneficial in the early stages of crop growth. No amount of care or work later can make up for neglect or improper tillage at first. In order to prevent the formation of a surface crust, a crop should be cultivated as soon after rain as is possible without injury to the soil.

EXERCISE

1. Lay off three plots side by side. In the first, break the soil to a depth of three or four inches, plant corn in the rough, loose soil, and do not cultivate. In the second plot, break the soil about six inches deep, plant corn, and cultivate three times to a depth of about four inches, as is done by some farmers who use a plow.* In the third plot, break the soil at least ten inches deep, make it fine, plant corn, and cultivate the surface soil not deeper than two inches after each rain, so as



PREPARING FOR A POOR CROP BY SHALLOW PLOWING



PREPARING FOR A GOOD CROP BY DEEP PLOWING

to keep a crust from forming. Compare the growth and yield of the corn in the three plots.

2. Just after you cultivate the second plot, carefully remove the soil from the roots of a plant in each plot and examine them.

3. Fill one flowerpot with wet, packed clay, and one with the same kind of soil in good condition. Set in each a geranium or other plant, and water and care for both in the same way. Is there any difference in the growth of the two?

4. Examine and compare the plowing of farmers in your neighborhood. Are straight furrows better than crooked ones? If so, why? What is the disadvantage of a very wide furrow-slice? of a very narrow one? Why should the furrow-slice be inverted?

5. Compare the tools and methods used by different farmers in the cultivation of the same crop. Tell which you prefer, and why.

CROP ROTATION

One-crop System. — In many sections, as in the grain states of the West and the cotton states of the South, the one-crop system is practiced. Farmers rely on a certain staple for their money crop. In this, all available land is planted year after year. This cropping is continued as long as the land yields profitable crops — often longer. There are prairie farms which have been in corn thirty years. Acres which once produced seventy-five bushels of grain now grudgingly yield fifteen, but spring after spring sees them plowed and planted again in corn.

Generally, however, the soil will not bear this continuous cropping, and it is left out every two or three years to 'rest,' as it is called. The processes of nature to some extent restore its wasted fertility, but sooner or later its crops cease to repay the labor of production. Then the land is left to wash in gullies or to grow up in weeds and bushes. There are thousands and thousands of acres of this 'run down' land in the United States.

Disadvantages of One-crop System. — In nearly all sections, the one-crop system is being abandoned by good farmers. It is bad for the farmer and worse for the farm.

The farmer risks everything for the year on the success or failure of one crop. On its profits he has to run his farm a whole year. A scanty harvest or a crop failure leaves him without funds for the expense of a second year. One-crop farmers are often poor. In the grain states of the West they mortgage their land, in the cotton states of the South they mortgage their crops, — and bear year after year the burden of debt.

The one-crop farm, like the one-crop farmer, is often poor. Slowly or rapidly its plant food is exhausted and its texture injured by the constant drain of the same crop and the same methods of cultivation.

If lands are to regain, keep, and increase fertility, rotation of crops must be practiced. This means that crops must be changed and must follow one another according to a certain system. Nature practices rotation. We see the place of field grasses gradually taken by pines; when the pines are cut they are followed, not by pines, but by oak and other hardwood trees.

Let us look into this subject of crop rotation.

Cotton as the One Crop. — Here, for instance, is an upland farm on which cotton has been raised year after year. The land is poor and yields a scanty crop. The soil is light in color and we find that it is lacking in humus. No wonder. It never receives any vegetable matter except the stalks and leaves of the cotton, or what is left of them by the cattle that 'pick up a living' in the fields in winter. Cotton is a rather weak-feeding plant, and it uses chiefly the plant food in the upper soil; some plant food is taken away in the cotton seed, and more is removed by air and water from the soil left bare during the winter. To supply these

losses and keep on raising cotton, the farmer must buy fertilizers.

He will tell you that his crop is subject to disease and insect pests, nor is it strange that they breed in the fields where the plant on which they feed grows year after year. The farmer will tell you that he has trouble about labor, too. He cannot afford to keep all the year as many laborers as he needs at certain times, especially during the cotton-picking season, and it is difficult to get them when needed. Probably he cannot tell you his exact expenses, but he knows that they are heavy and his profits small. In addition to paying laborers and buying fertilizers, often he has to buy feed for his horses and mules; these must be kept all the year, though they are not busy one fourth of the time.

If you ask this farmer why he does not plant less land in cotton, he looks at you in amazement. He answers that he would like to plant more; it is hard to get on as things are, and he could not make expenses if he planted less.

Let us see.

Cotton in a Rotation. — The farm adjoining this has the same natural conditions, but luxuriant crops grow on its fertile soil. One important element of its owner's success is his well-planned rotation of crops. His tilled land is divided into three parts, or 'shifts,' as farmers call them. On one he plants cotton, on one corn, on one cowpeas are drilled or sowed. These crops require planting and cultivating at different times, and so there is lighter and more constant work for man and team. Oats are sowed after the cotton. The cowpeas are gathered and the vines plowed under, or the vines are cut for hay and the stubble is plowed under. In either case, the land is improved in ways which are more fully explained on page 108. On this land is seeded a winter-growing crop, such as rye or barley; this keeps

the land from washing, and uses plant food which would otherwise go to waste. With the corn at the last working is seeded crimson clover, which is a winter-growing crop.

The second year, after grazing the rye or barley in the third shift, the farmer plows it up and plants that land in corn,—sowing, as before, crimson clover at the last working. He feeds or plows under the crimson clover in the second shift and plants it in cotton, later seeding this land in oats. When he cuts the oats on the first shift, he seeds cowpeas on the stubble, and when these are cut or picked, he sows rye or barley.

The third year he again changes the crops on his shifts. Corn and crimson clover come on the first shift, cowpeas and small grain on the second, and cotton and oats on the third.

The farmer is kept busy, but is never so much hurried as his neighbor who raises only cotton. Winter finds something growing on all the fields; the land is gaining instead of losing fertility. By change of crops and by plowing under green crops and stubble, humus and plant food are saved and supplied. This farmer has to buy less commercial fertilizers, and yet has better crops. Crop diseases and insect pests are less troublesome in his fields. He has plenty of feed for live stock; the hay and peas and grain he raises more than make up for his smaller crop of cotton.

In the long run, it will be found more profitable to grow a crop, such as cotton or tobacco, once every two or three or four years on a field than every year. The advantages of crop rotation are so great that the farmers who give it a fair trial do not return to the one-crop system. In most sections the most prosperous farmers are those who practice rotation of crops.

There are three kinds of crops which should have place in every rotation. First, of course, is the money crop to which

the main place is given; this is usually the one which prevailed under the one-crop system,—tobacco, wheat, corn, or cotton.

1. cotton oats	corn crimson clover	cowpeas rye or barley
2. cowpeas rye or barley	cotton oats	corn crimson clover
3. corn crimson clover	cowpeas rye or barley	cotton oats

Second, there should be grain and fodder crops to provide food for man and beast. Third, there should be at least one legume to supply humus and plant food.

Principles of Rotation.

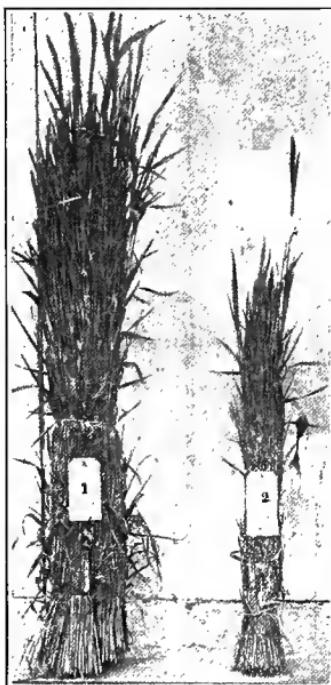
—There are no hard-and-fast rules as to the crops in a rotation. Yet the rotation should be arranged according to definite principles so as to secure certain advantages for the farm and the farmer.

First: Crops should rotate so as to give every year a money-market crop. It is better if a farmer can have two or more money crops, marketable at different seasons. Of course, the main one should be a profitable one. To determine the profitableness of a crop, the farmer must consider not merely selling price, but cost of production and market condition. The cost of production includes labor and fertilizers and the demand on soil fertility. It must always be borne in mind, in considering the profit and loss of crops, that the elements removed from the soil must be returned in some form. Tobacco costs much labor to produce, and makes great demands on the soil for plant food which must be returned in the shape of fertilizers and manures. The selling price must be high to make it profitable. Hay and grass, on the other hand, demand less labor and remove less fertility; thus they can be profitably sold at a lower price. If live stock be sold, or still better live-stock products, such as milk and butter, little fertility is removed from the farm, and the chief cost is in labor.

Second: Crops should rotate so as to secure most of their nitrogen from the air. This is done by growing legumes, such as clover and cowpeas. Their work in improving the soil is more fully described in the section on *Green Manures*. More and more, farmers are realizing the importance and the economy of raising legumes, and so avoiding partly or wholly the expense of buying nitrogen in fertilizers.

Third: Crops should rotate so as to have plants of different feeding capacities and habits of growth follow one another. The greater the difference in all ways,—growth, food needs, food-getting power, and methods of cultivation,—the better. Food unavailable to plants with shallow fibrous roots, such as wheat, is pumped out of the subsoil by plants with deep taproots, such as clover. Thus the drain of crop-feeding is divided between soil and subsoil. Different methods of cultivation required by different crops improve soil conditions. All soils need to be sometimes loosened, sometimes compacted.

Fourth: Crops should rotate so as to make the best use of the residue, or remains, of the preceding crop and of the manures and fertilizers applied. Coarse manures are generally most valuable when applied to strong-feeding crops to precede and prepare for weak-feeding ones. Clover, for instance, is a strong-feeding plant and it makes good use of stable manure; it stores



Courtesy of Alabama Agricultural Station

1, rye after velvet beans; 2, rye from an equal area, after sweet potatoes.

up nitrogen and leaves plant food in the surface soil. It is therefore valuable to precede a weak-feeding plant, such as wheat. Tobacco is another good crop to precede wheat. It is a tap-rooted plant and it leaves the soil in a good condition for the fibrous-rooted cereal.

Fifth: Crops should rotate so as to keep in check weeds and insect pests and fungous diseases. Certain weeds and insects flourish on certain crops. Moreover, plants grown a long period on the same soil lose vigor and ability to resist their enemies. These enemies are checked or destroyed by rotation of crops. Sometimes it is necessary to plan or change a rotation so as to reclaim land from these pests. Farmers change their crops and their methods of cultivation to check wilt diseases and weevils. By rotation of crops, lands can be freed of cattle ticks, so injurious to stock in the South.

Sixth: Crops should rotate so as to furnish abundance of food for all live stock kept on the farm. When the farmer buys feed, he has to pay not only the cost of production, but the producer's profit and the cost of marketing and transportation.

Seventh: Crops should rotate so as to keep land occupied. If a market or food crop is not being grown, there should be a catch, or cover, crop on the land. This will save and increase plant food, supply humus, and prevent the washing and leaching which cause far more loss of fertility than does cropping. Sandy soils and rolling land should never be left bare in winter. It is better for the farmer and the farm for them to be kept busy producing fertility to feed the next season's crops.

Eighth: Crops should rotate so as to secure for men and teams as even distribution of labor as possible. Where this is not done, labor is more expensive and more unsatisfactory. In the great wheat region of the West, work is constant and hard for two

or three months, then ceases almost entirely. There most unsatisfactory labor conditions prevail.

Some Good Rotations.—A favorite three-year rotation where wheat and root crops are grown is wheat, clover, rye, and potatoes. The wheat and clover are seeded in the fall. The wheat is cut the next summer, and the clover stands two years. The clover is followed by a winter cover crop of oats or rye which is grazed and followed by potatoes.

Where cotton or tobacco is the main crop, a good three-year rotation is the one described,—corn and crimson clover, cotton or tobacco, small grain, and cowpeas or soy beans.

A good four-year rotation is clover, wheat, and tobacco; in this the clover stands two years. Another four-year rotation is potatoes, oats, clover, and wheat. A five-year rotation which includes small fruits is corn, wheat and cowpeas, early potatoes and beans, and strawberries for two years.

Where dairy-farming and market-gardening are practiced, manures and fertilizers are largely relied on instead of crop rotation.

EXERCISE

1. Plan a rotation to bring in the staple crop of your section with regard to the principles explained.
2. Plan a rotation to bring in sweet potatoes as chief crop on sandy soil; tobacco as chief crop on loam; hay as chief crop on clay soil.
3. Plan a rotation to improve a clay soil that lacks humus; one to improve a thin, sandy soil.
4. Set aside two plots of equal size. Divide one into three parts and cultivate on it the crops in one of the three-year rotations described. On the other plot grow for three years the main crop in the same rotation.
5. Write an exercise on "crop rotation," illustrating it from your observation of the farms of your neighborhood.

GREEN MANURES; LEGUMES AND SOIL INOCULATION

Green Crops. — Green manures are crops, such as rye, cowpeas, and clover, plowed under when green to improve land. Sometimes the green crop is grazed or fed to stock or cut for hay, and the stubble is plowed under to improve the land. These crops benefit the soil's texture and moisture conditions, add humus and some plant food, and make available much food already in the soil. Humus is especially needed by light soils in humid climates. Without it, they never produce good crops. Usually, the cheapest way to get it is to grow it on the fields where it is needed. A soil is kept well supplied with it by proper rotation of crops and by stock raising.

'Catch,' or 'cover' crops, as these are called, may often be grown without interfering with other crops in a rotation. They keep the land from becoming infested with weeds in summer, and in winter they prevent the washing away of soil and the leaching out of plant food. Cowpeas is an excellent summer crop to follow small grain, such as wheat or oats. Where it thrives, crimson clover is an excellent winter crop. It can be seeded alone, or in such crops as corn, cotton, and tobacco, when they are worked the last time; in spring it may be cut or plowed under and the land planted in corn or other crops.

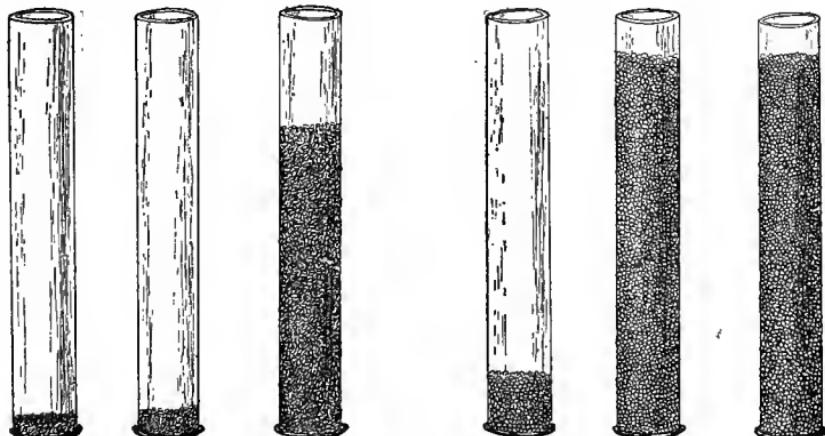
Legumes. — Both cowpeas and crimson clover are legumes, which are the best green crops for soil improvement. What are legumes, and how do they benefit the soil more than other plants?

Legumes, or pod-bearing plants, include cowpeas, vetches, beans, peanuts, al făl'fa, and the clovers. They are valuable as humus suppliers and as forage crops, but their greatest value lies



In the flowerpots on the left is wheat supplied, first, with potash; second, with potash and phosphoric acid; third, with potash, phosphoric acid, and nitrogen. The tubes below show the relative yield of grain.

In the flowerpots on the right is vetch supplied, first, with potash; second, with potash and phosphoric acid; third, with potash, phosphoric acid, and nitrogen. The tubes below show the relative yield of seed.



FERTILIZING EXPERIMENT WITH WHEAT AND VETCH

in the fact that they are nitrogen-gatherers. Nitrogen is a costly and scarce element of plant food, costing, in commercial form, about sixteen cents a pound. An average crop of peas or clover adds about one hundred and fifty pounds of nitrogen to each acre of soil.

Free Nitrogen. — Where do the plants get it? From the air. Over every acre of soil there are more than three thousand tons of free nitrogen. This is of no service to crops, such as the cereals, which have no power to use nitrogen until it is changed into certain compounds. With vast quantities of nitrogen around it, a plant may starve, just as a sailor may perish of thirst with the great ocean surrounding him. Nitrogen is there, water is there, but not in forms available to the plant and the man.

Tubercles. — Legumes, however, feed indirectly on this free nitrogen by means of certain forms of bacteria, which live in knots, called tubercles, on their roots. The decay of the tubercles leaves nitrogen in the soil. On different legumes and under different conditions these tubercles vary from the size of a tiny pin head to that of an egg. They are thought to be rootlets, changed in form by thousands and millions of bacteria.

Bacteria in Soils. — In soils where legumes have been cultivated, these bacteria are abundant. Where legumes have not been grown, they are apt to be lacking. In that case the legumes will produce a smaller crop and the soil will be less enriched. The bacteria increase rapidly, and often legumes thrive the second year on land where they failed the first. Bacteria may be supplied by sprinkling land with soil from a field on which has been grown the legume desired; soil from an alfalfa field must be used for alfalfa, from pea land for peas, and so on. Sprinkling the soil, or in *čc'u lat ing* it, as it is called, with soil from another field is troublesome and often inconvenient; it often introduces weeds and insect pests and fungous diseases.

Pure Culture of Nitrogen.—After many experiments by scientists, a method has been discovered of growing these bacteria, so as to give legumes a start on land where they have not been cultivated.

This is done by means of what is called a 'pure culture' of nitrogen; it supplies bacteria raised under conditions that make them depend upon the air instead of the soil for their supply of nitrogen. This 'pure culture' is applied to the seed or to the soil. It is similar in action to a yeast cake, and like yeast the bacteria must be raised carefully according to directions.

The practical value of this method is doubted by many scientists. Certainly it is not enough to inoculate the seed or the soil. The soil should be well prepared, and there should be supplied mineral food,—potash and phosphoric acid, and lime if the soil is acid. If these elements be furnished in abundance, the legumes make a rank growth.

EXPERIMENTS

1. Obtain the 'pure culture' from the Department of Agriculture or from your State Agricultural Experiment Station, and experiment with it. Fill two boxes with quartz sand which has been heated red-hot in order to burn out nitrates. Supply both with potash and phosphoric acid. Plant wheat in one, and in the other plant peas inoculated with the 'pure culture.' What happens to each when the nitrogen stored in the seed is exhausted?

2. Plant crimson clover seed in a paper box of soil from a field in which clover has been grown. When the plant blooms, put the box in water and soak the soil from the roots; examine the tubercles.

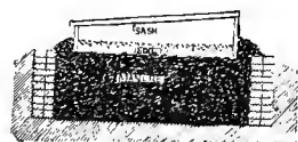


At the left, crimson clover on uninoculated soil; at the right, crimson clover on inoculated soil.

STABLE MANURE

Benefits of Manure.—Stable manure is the liquid and solid excrement of farm animals. We find the richest farms and the most prosperous farmers where stock raising is practiced and the manure is properly saved and utilized.

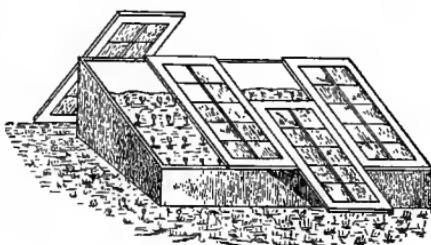
Stable manure increases the supply of plant food in the soil. It does this directly by supplying some elements, — nitrogen, potash, phosphoric acid, and lime, — and it does it indirectly by helping to change into available forms some unavailable elements.



CROSS SECTION OF HOTBED

It also improves the condition of the soil, binding together sandy soil and loosening clay. It enables a soil to retain more water and to yield it more fully and more gradually to plant roots. By the heat which it gives out in decaying and also by the heat which it absorbs from the air, it warms the soil. It does this to such an extent that 'hotbeds' of manure are used to hasten the germination of seeds and growth of plants.

Value of Manure.—The value of manure depends on the kind of animals which produce it, their age and food, the methods of saving and applying it. As a rule, the more concentrated the food of an animal, the more concentrated, and hence the more valuable, is the manure. The manure from poultry, hogs, and horses, which are fed concentrated foods, is more valuable than cow manure, which is produced chiefly from coarse, bulky



HOTBED, IN WHICH PLANTS ARE GROWING

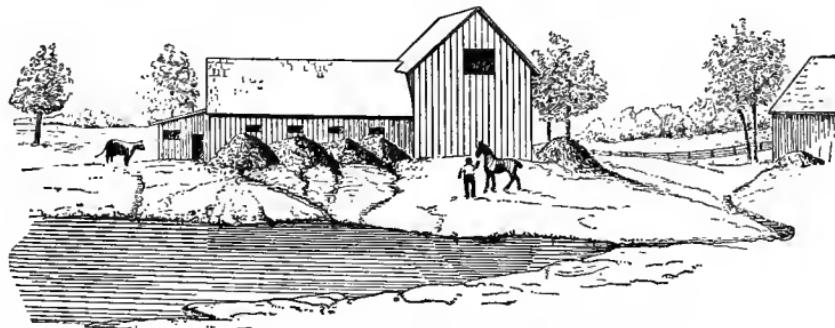
foods. Under good management, eighty per cent of the fertility in food can be returned to the soil in manure. The manure from old animals is more valuable than that of young ones, because growing animals retain more of the fertilizing elements, especially nitrogen, to build up their bodies.

VALUE OF MANURE, ANNUALLY, OF FARM ANIMALS

	PRODUCED	SAVED BY AVERAGE FARMER
Horse	\$27.00	\$10.00
Cow	19.00	6.00
Hog	12.00	4.00
Sheep	2.00	.75

Manure yields about one fourth of its value the first season. Its effects are more lasting than commercial fertilizers, which give up from one half to three fourths of their value the first season.

Sources of Loss.—Manure often loses half or more of its value from lack of proper care. There are three sources of loss.



LOSS OF MANURE BY EXPOSURE

The manure on this farm loses more than half its value before it is applied to the land.

Refer to the text and explain how and why this happens.

First: Manure loses by the escape of the liquid matter. This is more valuable than the solid matter, as it contains nearly all

the nitrogen and some of the phosphoric acid and potash. Its loss may be prevented by the use of the proper quantity and kind of absorbents, such as straw or leaves, to catch and retain it.

Second: Manure loses by exposure to rain. The liquid and some of the elements of the solid matter are leached and washed out. In manure exposed for several months to the weather, the loss of nitrogen and potash may amount to more than one half. When it is not desired to apply manure at once, it should be piled under cover or composted and kept moist.

Third: Manure loses through the escape of gases in fermentation, or 'heating' as it is called from the heat produced and given off in the process of decay. Fermentation is caused by the action of bacteria. If they are allowed to work unchecked, they set free in gases the most valuable elements of the manure. The process of fermentation can be checked by mixing the manure of different kinds of animals and by keeping the mass moist and well packed. When it is kept moist, the heat, instead of causing fermentation, is spent in evaporation; when it is well packed and trampled, fermentation is checked by lack of air. Manure is improved by fermentation if it be protected against loss of nitrogen.

Composting Manure. — Farmers often compost manure. This is done by making a heap composed of alternate layers of manure and of weeds, leaves, etc. The whole is put up in a cone-shaped heap to protect it against rain, and covered with a layer of dry earth to absorb gases. It needs to be occasionally repiled and wet thoroughly to keep in check the process of fermentation.

Where labor is scarce, it is often better to haul manure directly to the field where it is to be used, and to scatter it upon the land so as to let its fertilizing elements be embodied in the surface soil.

EXPERIMENT

Fertilize a row in your garden with stable manure that has been protected against loss by leaching, washing, and heating. Fertilize another row with the same amount of the same kind of manure that has been exposed to the weather. Plant both rows in corn and cultivate in the same way. What difference do you observe?

COMMERCIAL FERTILIZERS

Crop Removal of Plant Food. — Perhaps you have heard a farmer say, "That crop has taken a great deal out of the land." That is literally true. In the case of abundant elements, such as iron, it is a matter of no importance; there is always enough left. But you know there are some elements which are scarce in available forms. The phosphoric acid, nitrogen, and potash removed by crops must be replaced if the soil is to continue productive.

Supplying Elements Needed. — Much plant food can be supplied and made available by deep and thorough cultivation, by proper rotation of crops, and by raising legumes. For crops which make large demands on soil fertility and in order to give proper balance of plant food, a farmer sometimes finds it desirable to supply some elements in concentrated, readily available forms. For these purposes, he uses commercial fertilizers. By their wise use, farmers gain thousands of dollars; by their unwise use, they lose more.

Commercial Fertilizers. — What are the sources of these commercial fertilizers? Some are obtained from vast natural deposits in Germany, South America, the United States, and other countries. Others are the by-products of certain manufactures, such as gas from coal, and oil from cotton seed.

They contain plant food in a more concentrated and more directly available form than it exists in green and stable manures.

They are rarely so cheap or so good for the soil as natural manures; some injure soil-texture and water-holding power. Most of them, indeed, are crop stimulants rather than soil improvers.

Rules for Use. — Two rules should govern the farmer's use of commercial fertilizers.

First: To enrich his soil and increase his crop, he should depend chiefly on tillage, rotation of crops, and natural manures.



GRASS ON FERTILIZED AND UNFERTILIZED LAND

This grass was sowed in September. The field on the left received no further care; that on the right had in the spring a top dressing of 250 lb. of muriate of soda and 250 lb. of nitrate of soda to the acre, at a cost of \$18.68. The manured crop yielded 6,567 lb. of cured hay to the acre; the unmanured yielded 1,284 lb. The hay sold for \$16.00 a ton. What was the profit from the use of the fertilizer?

Second: He should supplement these with the proper amount of the commercial fertilizers that experience proves best and cheapest for his soil and his crops.

Guano. — One of the best commercial fertilizers is guano (gwä'no), which is especially rich in nitrogen and phosphoric acid. Guano is the manure and remains of fish-eating sea fowls. For countless centuries these birds frequented the rocky islands off the Pacific coast of South America. There they hatched and reared their young. Their manure and dead bodies accumulated, and in

that rainless, tropical climate the moisture evaporated, leaving the fertilizing elements uninjured. The ancient Peruvians knew the value of these deposits, and protected the sea fowls and their homes. It was forbidden under penalty of death to kill the birds or even to set foot on the islands during the breeding season.

About eighty years ago the first cargo of guano was sent to England, and experiments proved that it had a wonderful effect on crop production. Millions of tons were shipped until the best beds were exhausted. Deposits have been found in other places, but none so rich in nitrogen as the old beds off the Peruvian coast.

Nitrogen. — For soil nitrogen, a farmer should rely chiefly on raising legumes, on proper rotation of crops, on stock raising and the use of manures, and on deep plowing and thorough cultivation; thus bacteria supply the soil with nitrogen.

The chief commercial forms of nitrogen are: guano; nitrate of soda, which is a vast natural deposit in rainless districts of South America; sulphate of ammonia, which is obtained as a by-product in the manufacture of illuminating gas from coal and from other sources; cotton-seed meal, which is a by-product of the manufacture of cotton-seed oil; dried blood and tankage, which are by-products from slaughter houses; dried fish and fish scraps, which are by-products of fish-oil factories and canneries.

The value of fish as a fertilizer was known to our American Indians. You remember that Squanto taught the New England settlers that they could increase the yield of corn by putting a fish under each hill. This gave the grain the two elements it needed most — phosphoric acid and nitrogen.

Commercial nitrogen was until recently obtained entirely from natural deposits and products. Artificial nitrates are now being made by the use of electric furnaces. By these the nitrogen and oxygen of the air are made to unite, forming nitric acid.

Phosphoric Acid.—Many soils contain phosphorus in forms unavailable to plants; these soils need thorough tillage, and stable manure and lime to combine with the phosphates and form phosphoric acid. The chief commercial sources of phosphoric acid are guano, ground and crushed bones, and phosphate rocks.

There are large deposits of phosphate rocks in South Carolina, Florida, Virginia, North Carolina, Tennessee, and other states. These are supposed to be the accumulated remains of ancient animals. The phosphoric acid in them is insoluble and cannot be used by plants; it is made soluble, and so available, by being treated with sul phū'ric acid. Some preparations contain free sulphuric acid, and if these be used year after year on land, it will become 'baked' and lose, instead of gain, fertility.

The insoluble forms of phosphates, such as bones and untreated phosphate rock, decay slowly and should be applied some time before needed. They do not injure the soil, are slow and lasting in effect, and are especially useful for slow-growing crops.

Potash.—It is difficult to estimate the amount of available potash in a soil, as plants vary greatly in their ability to get it; it is unavailable for some, where others collect all they need. Tobacco, grass, potatoes, legumes, and fruit trees use much potash.

The chief commercial sources of potash are wood ashes and the products of the Stäss'furt mines in Germany. These mines are in a vast salt bed formed probably by the evaporation of water from an inland sea, leaving the substances leached from the land. Potash is shipped from these mines in various forms, such as kāin'it, mū'riate of potash, and sūl'phate of potash. Common salt is the chief impurity in kainit and in muriate of potash. Sulphate or nitrate of potash is used on such crops as tobacco, potatoes, and fruit, of which the quality would be injured by the salt in muriate of potash and kainit.

Calcium. — Calcium is an essential plant food of which there is generally enough in the soil for plant needs. Applications of it, however, in the form of lime, are usually beneficial. One of the most useful effects of lime is in correcting acidity of soils. From various causes, there sometimes form in soils acid compounds, which



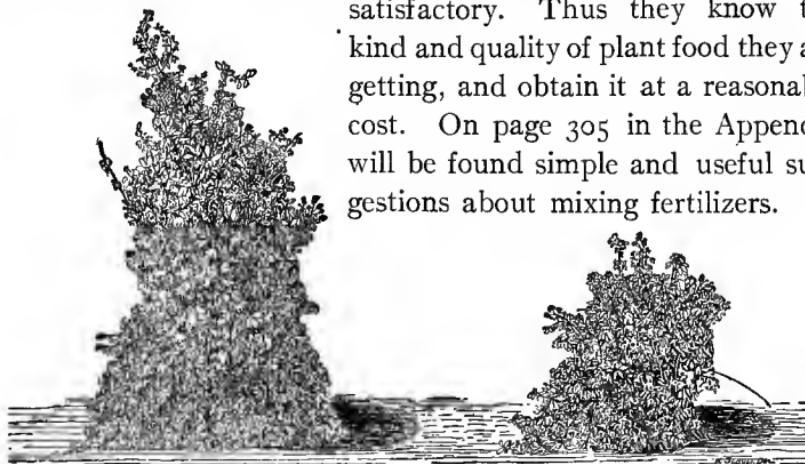
A LIME-SPREADING MACHINE AT WORK

are injurious to plant growth. Such soils will not produce good crops. It is necessary to 'sweeten' them, as farmers say. This is done by applying lime, which combines with the acids and destroys the injurious compounds. Lime improves soil texture, sets free much unavailable plant food, and prevents many fungous diseases.

The effect of lime is largely a forcing one. Therefore it should be used as a supplement to other plant foods, not as a substitute for them. A wise old proverb says,—

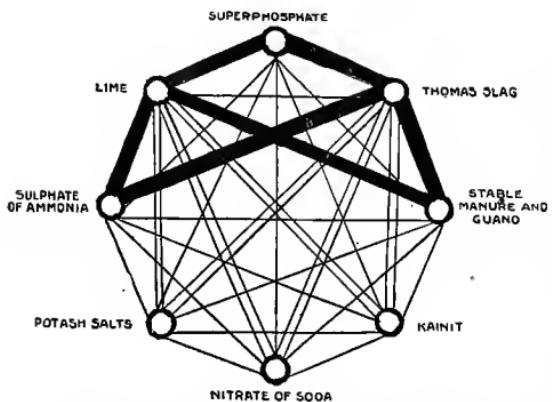
“ Lime and marl without manure
Will make both farm and farmer poor.”

Mixing Fertilizers.—Many farmers buy materials and mix fertilizers according to formulas which tests and experience have proved satisfactory. Thus they know the kind and quality of plant food they are getting, and obtain it at a reasonable cost. On page 305 in the Appendix will be found simple and useful suggestions about mixing fertilizers.



ALFALFA

The alfalfa on the left was from limed land; that on the right was from an equal area of unlimed land. Legumes are usually benefited by applications of lime.



In this diagram the dark lines unite names of materials which should never be mixed; the light lines unite those which may be mixed at any time; the double light lines unite those which should be applied immediately after mixing.

Field Tests.—By making field tests, a farmer can learn what fertilizers suit the special needs of his soil and his crops. It is a good plan to set aside for a test eight plots, each twenty-one feet and four inches wide and one hundred and two feet long, containing one twentieth of an acre. They should be separated by strips of land about three feet wide,

to prevent the fertilizer used on one plot from affecting the adjoining plots.

The fertilizers should be applied as illustrated in the diagram. They can be mixed with fine earth and drilled in the rows. The plots should be cultivated in the same way and planted in the same crop, the one for which the farmer usually buys fertilizers. If he uses them largely on several crops, it will prove helpful and economical to make the test for each one. If potatoes or tobacco be the test crop, sulphate of potash should be used instead of muriate of potash.

The test plots may be made smaller, the quantity of fertilizers being reduced accordingly.

Cost of Fertilizers.—In buying or in mixing fertilizers, the farmer should try to get as many pounds of available plant food as possible for the money, not as many bags of material. The freight and trouble of handling a ton of kainit containing one hundred and twenty pounds of plant food are as great as those on a ton of muriate of potash containing a thousand pounds. A fertilizer at forty dollars the ton may be, and often is, cheaper than one at twenty dollars the ton, on account of supplying over twice as much plant food at the same cost for freight and hauling.

Guaranteed Analysis.—To protect the farmer against fraud,

8lb. Nitrate of Soda. 1

8lb. Muriate of Potash 2

16lb. Phosphoric Acid. 3

8lb. Nitrate of Soda.
8" Muriate of Potash. 4

8lb. Nitrate of Soda.
16" Phosphoric Acid. 5

8lb. Muriate of Potash
16" Phosphoric Acid. 6

8lb. Nitrate of Soda
8" Muriate of Potash.
16" Phosphoric Acid. 7

2 bu. Lime 8

FERTILIZER FIELD TESTS

many state laws require that the guaranteed analysis, or formula, of a fertilizer shall be placed on the bag containing it. At the prevailing prices of unmixed materials, a pound of nitrogen is worth about sixteen cents, a pound of potash about five, and a pound of phosphoric acid about four and a half. If a farmer understands a fertilizer formula, he can tell how many pounds of each he is getting in available form; by the price of the ton he can tell whether or not he is paying a reasonable price, including the manufacturer's profit for mixing and bagging. If he be not willing to take time and trouble to learn the A B C of the matter, his purse, and often his crop also, will suffer.

A few years ago a 'natural plant food' was widely advertised and extensively sold at from twenty-five to twenty-eight dollars the ton. So much of the plant food which it contained was in insoluble and unavailable forms that the real value of the mixture was one dollar and fifty-two cents the ton. The printed formula was given on the bag, as required by law. But to the man who did not understand it, this was of no more value than so many Greek letters.

EXERCISE

1. To find out if land is acid, take some soil from two to four inches below the surface and moisten it thoroughly. Put in it a slip of blue litmus paper and leave it there several hours. If the blue paper turns red, the soil is acid and needs lime.
2. Lay off eight plots and make the field tests described on page 120. Remember that weather will affect the results; the experiment should be repeated several times. You may modify the experiment by using more or less of certain substances, so as to learn how to attain most economically the best result for a given crop.
3. Are commercial fertilizers used in your locality? For what purposes?
4. Get samples of different commercial fertilizers and test them, comparing results on same soil with same crop plant.

OUTLINE OF CHAPTER FOUR
FIELD, ORCHARD, AND GARDEN CROPS

Crop Raising:

Conditions determining crop:

Climate, soil, labor, market

Profits lie in

Cultivating well, in proper way, and at proper time

Avoiding waste and unnecessary expense

Forage Crops:

Uses:

Supply green and dry feed for stock

Some grasses:

Blue grasses, meadow fescue, redtop or herd's grass, orchard grass,
timothy, Bermuda

Corn, sorghum

Some legumes:

Clovers, cowpeas, alfalfa, vetches, soy beans, Canada field peas,
velvet beans, peanuts

Cutting and curing hay

Cereals:

Uses:

Grain for food

Stalks and leaves for forage

Requirements:

Fertile soil, clay or loam preferred

Much moisture

Improved by

Seed selection

Good tillage

Cross breeding

Corn:**Cultivation:**

Deep plowing before planting

Shallow cultivation of crop

Wheat:**Cultivation:**

Deep, firm seed bed with fine mellow surface

Oats**Rye****Barley****Rice****Cotton and Other Fiber Plants:****Uses:**

Fiber for clothing

Seed for oil, stock food, and fertilizer

Cultivation:

Deep plowing before planting

Shallow cultivation, not continued late

Improved by

Seed selection

Good cultivation

Cross breeding

Cotton:**Special requirements:**

Long growing season

Even rainfall

Much sunshine

Well-drained soil, loam preferred

Flax**Hemp****Tobacco:****Uses:**

Leaves for smoking and chewing

Stems for snuff

Requirements:

Soil and climate adapted to type desired

Cultivation, fertilizing, and curing adapted to grade desired
Cultivation:

Deep plowing before planting
Shallow, thorough cultivation of crop

Improved by
Seed selection
Cultivating according to requirements

Sugar-producing Plants:

Sugar cane
Sorghum
Sugar beets

The Orchard and its Care:

Our common fruits
How fruit trees are grown
Orchard location
Selection of varieties
Transplanting
Cultivating
Fertilizing
Spraying
Thinning fruit
Pruning trees

The Vegetable Garden:

Location and cultivation
Market gardening or truck farming
Our common vegetables
Berries, bush fruits, and grapes

The Flower Garden:

Improvement of flowers
Annuals
Biennials
Perennials

PRINCIPAL CROP PLANTS

Grass family	Rose family	Nettle family
Corn or maize	Apple	Hops
Wheat	Pear	Morning-glory family
Oats	Quince	Sweet potato
Rye	Peach	Legume family
Barley	Plum	Clovers
Rice	Apricot	Cowpeas
Sugar cane	Cherry	Alfalfa
Sorghum	Strawberry	Vetches
Timothy	Raspberry	Soy bean
Blue grasses	Blackberry	Canada field pea
Redtop, or herd's grass	Dewberry	Velvet bean
Fescues		Peanut
Orchard grass		Garden pea
Goose-foot family	Citron family	String beans, or snaps
Beet	Orange	Shell beans,—lima, navy,
Spinach	Lemon	and butter beans
Mangel-wurzel	Lime	
Melon family or cucurbs	Carrot family	Vine family
Gourd	Carrot	Grapes
Cucumber	Parsnip	
Muskmelon	Parsley	Mallow family
Watermelon	Celery	Cotton
Squash		Okra
Cymling	Nightshade family	Mustard family
Pumpkin	Tomato	Mustard
	Eggplant	Turnip
	Pepper	Radish
	White potato	Cabbage
	Tobacco	Cauliflower
Sunflower family	Lily family	Rape
Artichokes	Onion	Cresses
Lettuce	Asparagus	
Salsify		

CHAPTER FOUR

FIELD, ORCHARD, AND GARDEN CROPS

CROP RAISING

Principles not Methods. — In this chapter you will be told little about special methods of cultivating special crops. These are to be learned by observing and practicing them in connection with the growing crop. Methods vary with season and with soil, as well as with crops: what is right in dry weather, may be wrong in wet; what is beneficial on a sandy soil, may be injurious on clay. Instead, then, of studying special methods, let us look into the principles which underlie crop raising and govern all good and successful farm work.

Let us first consider briefly our agricultural plants.

Plant Families. — Plants are divided by botanists into families, or orders, which include those of common origin. There are two hundred families of flowering plants, including over a hundred thousand species. A few of these families furnish our crop plants, which have many wild relatives, some of which are poisonous. Our crisp celery is close kin to the poisonous hemlock, the white potato to the deadly nightshade. It is useful to know these kinships. While related plants may differ greatly in appearance, they need similar food and care and are subject to the same diseases and insect enemies.

The grass family is a large and useful one. In it are included sugar cane, sorghum, and the cereals, as well as numerous pasture

and hay grasses. These plants have fibrous surface roots, long, narrow leaves, and jointed, hollow or pithy stems. Their flowers are usually small and scentless, as they depend upon the wind to carry their pollen.

You have already been told something about the legume, or



PRODUCTIVE AREAS OF THE PRINCIPAL AGRICULTURAL STAPLES OF THE UNITED STATES

pod-bearing, family, which has the power of using free nitrogen by means of bacteria that live in the tubercles on the roots.

The rose family, which gives us our most beautiful flowers, is the great fruit family of the north temperate zone. On page 126 is a table of our principal crop plants, classified according to families.

Crop Development.—To Asia we owe most of our food plants. They have had their qualities developed by hundreds, even thou-

sands, of years of cultivation. By cultivation they have been given a much wider range of soil and climate than their wild ancestors had. But they still have preferences, often very decided ones, as to climate, soil, moisture, and other conditions. Their yield is largest in quantity and best in quality when these preferences are regarded, and therefore it is to the farmer's interest to consider them. His profits lie in producing at the least possible cost the best possible crop.

Climate. — Climate is a matter of main importance. A warmth-loving plant, such as cotton, will not grow in northern climates; certain varieties of wheat do not flourish in warm sections. Crimson clover seldom does well in the North, and Canada peas are usually unsatisfactory in the South.

Soil. — Soil has a decided effect on crops. On a sandy soil most grain crops, especially wheat, are small in quantity and inferior in quality; on that soil tubers and root crops thrive. On a clay soil, on the other hand, root crops do not develop well, but wheat and most other cereals and grasses thrive.

Moisture. — In their moisture requirements, also, plants vary widely. The drought-enduring Kafir corn will grow where most plants would die for want of water; moisture-loving rice will thrive where most plants would be drowned.

Conditions Determining Crops. — Soil and climate, then, determine the possibility of the crops on a farm; but it is market and other conditions which, to a large extent, determine their profitability.

The eastern states, where there are many towns and cities and a network of railroads, are largely occupied with dairy farming, poultry raising, and market gardening. In the South, where land is plentiful and labor has been abundant, are raised the great labor-demanding staples, tobacco and cotton. In the West, where

land is plentiful but labor scarce, are raised vast crops of grain and great quantities of stock.

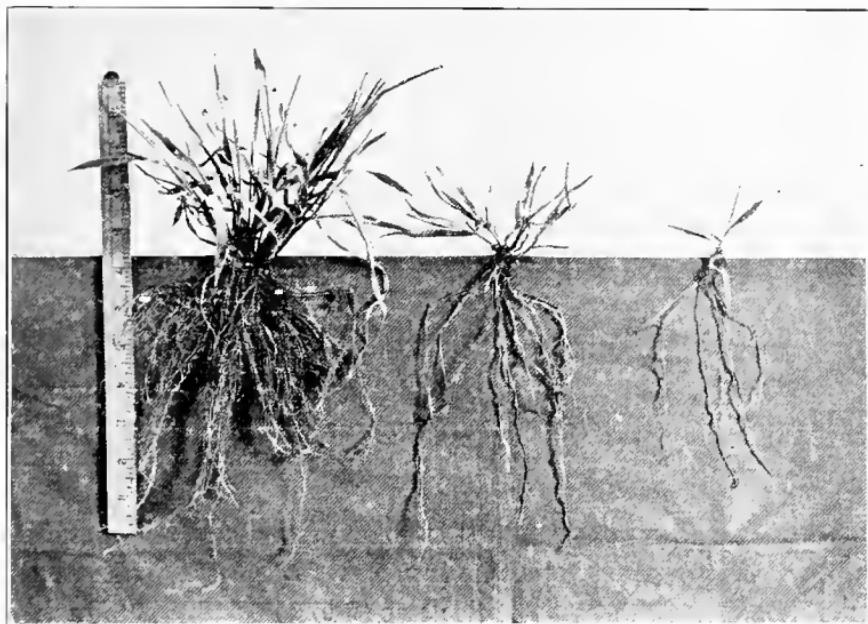
It will not do to grow a crop simply because it was a profitable one for our fathers and grandfathers. Labor and market conditions change, and the successful farmer, like the successful man in other fields of business, must adapt himself to circumstances. New England was once the wheat farm of the United States. Since large crops of grain have been produced on the prairie lands, New England farmers have found it more profitable to raise other crops. In turn, the vast wheat crops of the Northwest will probably compel the prairie states to seek profit in other branches of agriculture.

Changed labor conditions have brought about changes in southern farming. Deprived of the vast fixed element of slave labor, the landowners have been forced to reduce their acreage of cotton and to raise at home their food supplies. They are finding profit in diversified farming and stock raising.

Methods of Cultivation. — Special methods of cultivation depend largely on soil and season, and on the habits of growth and feeding powers of each special crop. There are, however, some general principles applicable to most cases. A deep, fertile seed bed and thorough tillage rarely fail to pay their cost, and a profit besides.

Season for Planting. — Other things being equal, the most profitable crop is the one planted at the most favorable season. In sections subject to summer drought, it is important to plant crops as early as possible. This gives them the advantage of the spring and winter store of moisture, and enables them by early growth and vigorous condition better to resist dry weather. The cultivation of a crop should put it in the best possible shape for the average and usual conditions of temperature and moisture of the section.

It is important for sake of both the crop and the soil to utilize favorable conditions. The successful tobacco grower works early and late to get his crop transplanted during a favorable season. A grain grower considers carefully the condition of his seed bed.



Courtesy of Nebraska Agricultural Station

AVERAGE PLANTS FROM THREE FIELDS OF GRASS

The plant on the left was seeded in September; the others were seeded later and did not get well rooted before winter.

Any good farmer can give you instances drawn from his own experience which prove that it pays to cultivate a crop well, and that it is important to plant and work a crop at the right time, when seasons are favorable.

Business Methods. — Farming demands for its successful pursuit the same qualities and methods required for success in other

occupations, — industry, intelligence, energy, and system. A manufacturer knows to a fraction of a cent what profit he is making on every bolt of cloth that his mill produces. If he finds that he is working at a loss, he increases his selling price, cuts down wages, or closes his mill.

Farming is a business in which more money is invested than in manufacturing or any other industry in the United States. Does a farmer know at what price he can afford to sell wheat and tobacco, or pork and beef, unless he knows what it cost him to raise them? Can he tell what crop is most profitable unless he knows, in each case, the cost of production as well as the selling price?

Keeping Accounts. — He should keep accounts as carefully as does the manufacturer. He should make a record of the cost of each crop, labor of man, team, and tools, quantity, composition, and cost of fertilizers, yield, and selling price. He should keep account of all his live stock, value of food, and returns in meat, milk, wool, and other products.

Increasing Profits. — Like the manufacturer, he must change his methods if he finds that he is working at a loss. If he cannot sell a product for a paying price or cut down cost so as to make it profitable, he should stop raising it. Profits can often be increased by foresight and good judgment in planting, cultivating, and marketing crops so as to improve their quality or to get them on the market at a favorable time. It is usually more profitable to sell, instead of raw products, articles made from raw products, — that is, to sell wool instead of hay, milk or butter instead of fodder.

Reducing Expenses. — By studying and applying the principles underlying the feeding of plants and animals, a farmer can reduce the cost of crop production and stock raising. This reduction, of course, increases his profits.

By-products. — All by-products on the farm, such as manure and ashes, should be used so as to get their full value. Advantage should be taken of processes to save material that formerly went to waste, such as cotton seed and cornstalks.

These matters may seem small, but they are important. All waste, all unnecessary expense, are so many dollars and cents deducted from the farmer's profit. Does he buy seed which he could as well or better raise at home? The cost comes off his profit. Does he hire incompetent laborers and so fail to get his work done at the proper time in the proper way? The so-called economy is an expense reducing his profits. Does he sleep late in the morning and loaf in the afternoon when his crops need him? The indulgence makes a heavy deduction from his profits.

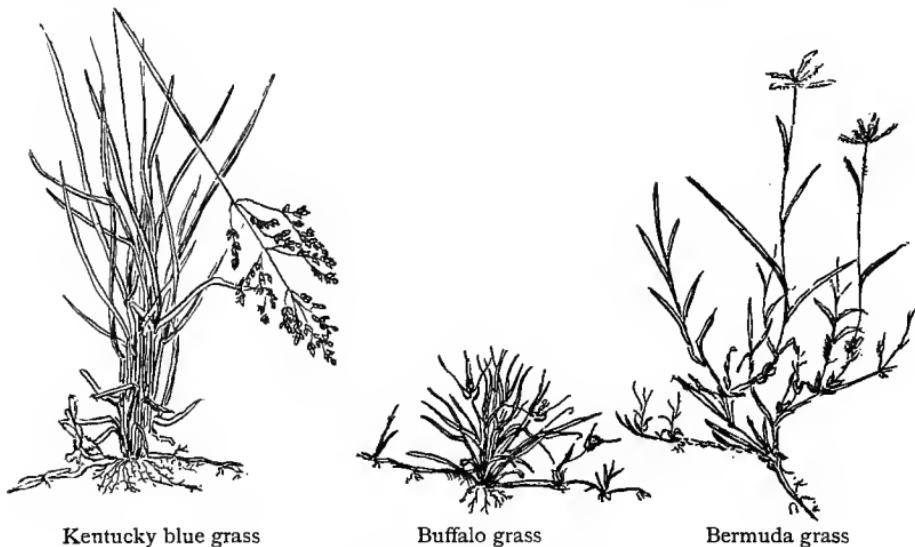
Exercises are given in connection with the special crops which follow.

FORAGE CROPS

Uses of Forage Crops. — As forage crops, we group those plants which are used as green or dry feed for horses, cattle, sheep, and other stock. These differ widely in growth and habits; they have one quality in common, — they produce luxuriant and succulent leaves and stems.

These forage plants are used in different ways. Sometimes they are sowed on land to form pastures where stock can graze. Sometimes they are fed as soiling crops, — that is, they are cut and fed green. Sometimes they are cut green, but instead of being fed at once, they are put away in air-tight buildings, called *silos*, to furnish green feed in winter. This *silage*, as it is called, is especially relished by dairy cattle. Sometimes the crop is allowed to stand until nearly ripe, and then is cut and exposed to the air and sun to dry so as to make hay.

Grasses.—Among the best pasture and hay plants are some members of the grass family. Those that spread by means of rootstocks or underground stems are especially adapted to pastures. Plants that spread by the seed alone would soon be killed by close grazing, which prevents their maturing seed. Among the best pasture grasses are the blue grasses, meadow fescues, orchard



THREE GOOD PASTURE GRASSES

grass, reedtop or herd's grass, and Bermuda grass. Redtop and timothy make excellent hay.

Many farmers sow on pasture land and hayfields a mixture containing several varieties of grass. This produces a larger crop and exhausts the soil less than one variety, because different grasses have different feeding habits and requirements. A favorite mixture is timothy, reedtop, orchard grass, and clover.

Most of the true grasses flourish best in cool climates and on fertile soil, especially on limestone soils.

Bermuda Grass.—In the South, Bermuda grass makes excellent summer pasture. Where year-round pasturage is desired, the Bermuda sod is harrowed and sowed with bur clover or hairy vetch to furnish winter grazing. Bermuda grass matures seed only in tropical countries; in temperate regions it spreads by means of its underground stems which take root at every joint. Owing to this habit of growth, it bears close pasturing without injury. It grows on almost any soil, however poor, and is especially valuable on thin, rolling lands disposed to wash. Bermuda is a sun-



THE PRODUCT OF A GOOD PASTURE

loving grass and dies when shaded. It can be killed in a season or two by a sowed crop, such as cowpeas.

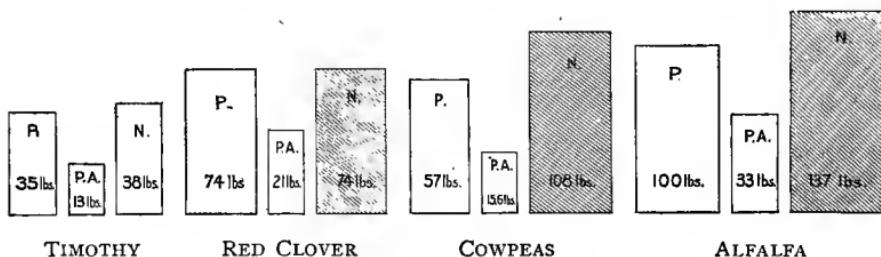
Corn.—Corn, which is our most valuable grain plant, is also our chief forage crop. Its uses and cultivation are described on page 140.

Sorghum.—In the South and Southwest, especially in semi-arid lands, Kafir corn and other varieties of sorghum are much used for forage. Sorghum resembles corn in growth, but is a stronger feeder and so thrives better on thin land. It endures extremes of heat and cold well, and resists drought that would kill corn.

It is a valuable hay crop in sections where redtop, timothy, and clover cannot be grown.

Rape. — Rape is a valuable crop for pasturing and soiling. It is easily grown and furnishes a large amount of forage that is especially relished by sheep and hogs. In the South it supplies late fall and winter grazing, and at the North cheap summer forage.

Legumes. — The most profitable fodder crops are legumes. They do double work, — fertilizing the soil, as you have learned,



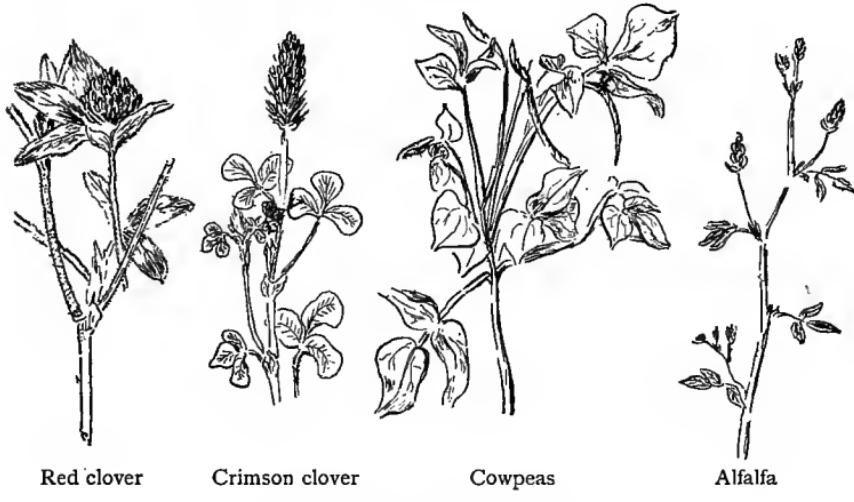
This diagram shows the amount of potash, phosphoric acid, and nitrogen, as indicated by initial letters, removed from an acre of soil by different hay crops. It is estimated that timothy will yield two tons of cured hay to the acre; red clover, two tons; cowpeas, two tons; alfalfa, three tons. The shaded figures indicate that the legumes, under proper conditions, get their supply of nitrogen from the air.

and also furnishing a large yield of excellent feed. Besides luxuriant foliage, many of them produce seeds having a high food value. They are strong-feeding plants, and their long roots pump up food that is out of reach of shallow-rooted plants.

In the large legume family are members adapted to widely different conditions. Red clover is the one most widely grown in the North, cowpeas and crimson clover in the South, and alfalfa in the West. No one of them, however, is limited to one section.

Red Clover. — Red clover is a perennial which is usually cultivated as a biennial. It makes a light yield the first season, and a heavy yield the second one. It is often sowed with grasses. The

clover dies the second year, leaving the field in grass. Clover should be cut for hay before the first blossoms turn brown. If cut before the seeds form, it will put out again and, in its efforts to seed, will make a heavy second crop. If cut late, after the seeds form, the second crop will be light. Mammoth clover is a rank-growing variety of red clover.



Red clover

Crimson clover

Cowpeas

Alfalfa

FOUR VALUABLE LEGUMES

Crimson Clover. — Crimson clover is an annual used as a forage crop in the central and southern states. It requires a mild climate and thrives on lighter soil than other clovers. It is sowed in the summer or fall, furnishes a valuable winter cover crop, and matures in the spring; often it is cut or plowed under to give place to a crop of cotton, tobacco, or corn.

Cowpeas. — Where it thrives, the cowpea is one of the best forage crops and soil improvers. It is a tender, strong-feeding annual. It grows better on thin, sandy soil than any other forage crop, and adapts itself to different conditions of soil and moisture.

Its deep roots get water and plant food from the subsoil. The cowpea grows rapidly, and in three months adds to the soil two thirds as much fertility as does red clover in eighteen months, besides producing a larger quantity of hay of equal feeding value.

Soy Bean. — The soy bean is a legume with many of the good qualities of the cowpea. It has the advantage of an upright growth and greater ability to resist drought.

Alfalfa. — Alfalfa is a wonderfully productive legume. It is the principal forage plant on the irrigated lands of the West. It can be grown in all sections of the United States, where the soil is properly prepared and inoculated. In some of the eastern states it is called *lu cérne'*, the name by which it is known in Europe. Alfalfa is the Arabic name used by the Spaniards, who introduced it into Mexico.

Alfalfa roots descend ten feet, or deeper, and use food and water out of reach of most crops. The land for it must be fertile and well drained. Alfalfa is a slow-growing plant and needs to be protected against quick-growing weeds. It should be kept mowed and free from weeds.

It does not reach its prime for three or four years, but produces from three to seven cuttings of hay every year for ten, fifteen, twenty years, or longer. If allowed to bloom and form seeds before it is mowed, its growth and vigor are lessened.

Other Legumes. — There are many other legumes used more or less extensively for pasturage and hay. Canada field peas and Alsike, or Swedish clover, require a cool climate; velvet beans require a warm one; vetches and Dutch, or white, clover thrive in both.

The peanut is a legume which is cultivated chiefly for the nuts. These are used for food and candy making, and for an oil re-

sembling olive oil. The vines, properly cured, make excellent hay, which is relished by all stock. Peanuts are often grown as a crop to be harvested by hogs. An acre of peanuts will make more pork than an acre of cowpeas or corn.

The soil should be kept loose by cultivation till the vines run freely. The plant flowers like a pea on the vine and then forms the nut at the end of the flower spike. This turns down into the ground and matures underground. The crop is harvested before frost, and the vines are shocked around poles. When dry, the nuts are picked off.



Courtesy of West Virginia Agricultural Station

A CROP OF TIMOTHY HAY WHICH YIELDED 8,527 LB. TO THE ACRE

Curing Hay.—The feeding value of hay crops depends largely on the time of cutting and the method of curing, or drying. Cut too early, plants are immature, sappy, and lack nourishment. Cut too late, the nourishment has gone to form seeds, and the stems are hard and woody. When it flowers fully, the whole plant is in the best condition for hay, full of nourishing juices.

It requires care and experience to cure hay properly. Much depends on the weather before and during the season of curing.

In a dry season hay cures easily. If it continues wet and plants are full of sap, care is needed to prevent mildew and rot. If cutting is followed by cold, wet weather, the crop will be injured or lost in spite of care.

EXERCISE

1. Collect specimens of true grasses and legumes. Compare their different parts,—roots, stems, leaves, and blossoms,—and make drawings of them. How is the pollen of legumes carried? How is that of true grasses conveyed?
2. What are the best pasture and hay crops of your section?
3. You will enjoy raising some peanuts and observing the plants' habits of growth. The small Spanish peanuts are productive and are easy to raise.

CORN, WHEAT, AND OTHER CEREALS

Cereals.—Cereals are plants of the grass family which are cultivated for their seed or grains. Among the most widely cultivated ones are corn, wheat, oats, rye, barley, and rice. During the early stages of growth there is much nourishment in the stems and leaves of cereals, and they are sometimes cut then for green feed or hay. Usually, however, they are allowed to ripen their seeds,—the grain crop so valuable for food. Much of the plant's nourishing substance is stored in the grain, but the leaves and stalk are still useful for forage.

Corn.—Corn, or maize, our great American cereal, is probably a native of tropical America. Long before Columbus crossed the ocean, it was cultivated as a bread grain by Indian tribes in the North and South, the East and West; and still from Maine to Florida, from Massachusetts to California, the summer sun shines on broad, waving fields of corn.

The average annual crop of the United States is over two and a

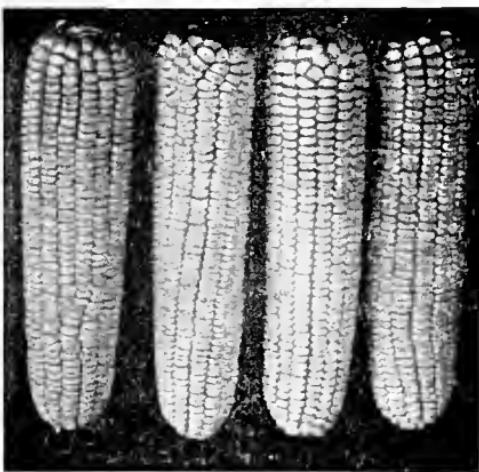
half billion bushels of grain,—three fourths of the world's crop. This is used as food for man and beast, and as material for the manufacture of starch, alcohol, and many other products.

The grain, however, does not form more than half the value of the corn crop. The leaves and husks, or shucks, and stalk contain more nourishment than those of most other cereals, and furnish a vast amount of forage; one sixth of the nourishment of the plant is in the stalks.

Paper and pasteboard are made from cornstalk fiber, and the pith furnishes material for linoleum and the packing for gunboats. Cornstalks are a valuable source of commercial alcohol. This is alcohol made unfit for drinking, but useful for light,

heat, and power. Since the government tax has been removed from commercial alcohol, corn growers have a new source of profit and of cheap power, light, and fuel. The cornstalks from an acre of corn yielding fifty bushels of grain produce about one hundred gallons of alcohol.

Range.—Corn, being a tropical plant, thrives best in a warm climate and on a moist, fertile soil. It has, however, such power of adapting itself to its surroundings that it has a wide range of soil and climate, and it grows in all sections of the United States. Indeed, the largest average yield of grain in the country is in New England, with its poor soil and short growing season.



Courtesy of Kentucky Agricultural Station

UNIFORM EARS OF CORN

There it is given the thorough tillage to which all cereals respond.

Cultivation. — The cultivation of the corn crop should begin before it is planted. The plowing should be deep and thorough. The corn should be planted as soon as the ground is warm enough; general experience is that early planting gives the best yield. Growing conditions are usually more favorable in the spring, and an early crop is less often injured by drought. Flat, shallow cultivation is best, except on wet lands where ridge cultivation is needed for drainage. Deep plowing breaks off the



A FIELD OF CORN THAT PRODUCED ONE HUNDRED AND THIRTY BUSHELS
TO THE ACRE

roots near the surface that are busy getting air, water, and food for the plants. This lessens the crop yield. In dry sections corn is often 'listened,' — that is, it is planted in furrows which are gradually filled by cultivation so that the roots range deeper and secure more moisture.

Saving Corn Forage. — Farmers are naturally desirous of saving both the forage and the grain of this valuable crop. Some pull the unripe leaves for fodder and cut the tops above the ears. But this requires a great deal of labor and lessens the yield of grain. You can easily see why it is so. You have learned how important the foliage is to a plant. You would never pull the leaves off a

grape vine and expect it to mature a full crop of fruit; neither can this be done with corn. If, however, the stalks be left in the field until the grain is mature, the forage loses much of its value.

It has been found most profitable to cut the whole stalk before it is quite ripe. The leaves and stalk then continue to feed the grain and mature it without much loss; thus both grain and forage are saved.

It is a laborious undertaking to remove the corn from these cut



CULTIVATING CORN

stalks, shuck or husk it, and cut the stalks for forage. Sometimes the stalks are fed whole, as 'stō'ver,' but there is much waste, because their hard fiber keeps them from being fully utilized for food. There are machines which remove and husk the corn and cut or crush the stalks into a coarse hay which is a palatable and nutritious fodder.

Fertilizers. — Some plants when they get half enough food mature half a crop. Corn, however, does not. When it is dwarfed by poor soil, it produces either no grain or a small and inferior crop. Therefore poor land should be improved by legumes, manures, and fertilizers before it is planted in corn.

Place in Rotation.—As corn removes humus and nitrogen from the soil, it should follow and precede crops which supply



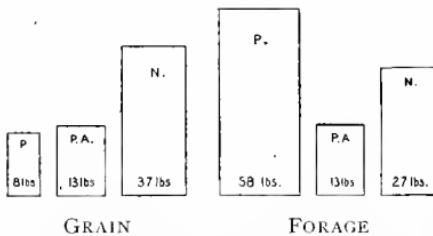
CORN ON SOIL TOO POOR TO YIELD A PROFITABLE CROP

one or both of these. Some good farmers sow rye or crimson

clover in the fall on land to be planted in corn the following spring, and plow under the rye crop or clover stubble.

Improvement.—The average yield of corn in the United States is only twenty-four bushels to the acre. It is an easy crop to improve in yield and in quality. It is estimated that

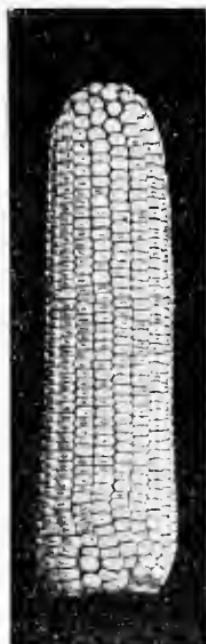
the yield to the acre could easily and quickly be doubled with very little increase in work or expense by improving the seed,



This diagram shows the amount of fertility removed from an acre of soil by a crop of corn yielding forty bushels of grain and 3500 lbs. of forage.

the condition of the soil, and the methods of cultivation. Thus each farmer could raise as much corn as he is now producing on half the land with little more than half the labor.

Seed Selection.—It is important to select seed corn in the field, so as to choose ears from healthy, productive plants. A farmer planted half of his field with seed selected in the field and half with seed selected from the crib containing his best corn. Soil and cultivation were the same. The seed corn from the crib yielded eighty bushels to the acre; the field-selected seed yielded ninety-six bushels.



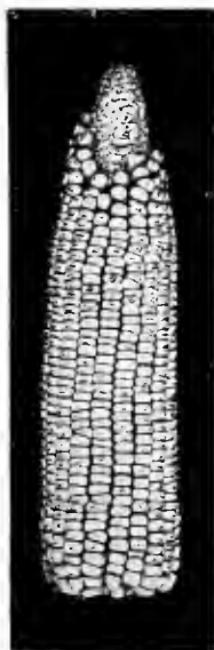
A good ear of seed corn

For seed, the best ears should be selected from the best stalks. The plants should be stout and healthy, well provided with leaves so as to give a good yield of fodder. The stalk should bear two or more good ears, which point downward when ripe. The size and shape of ear and kernel, the arrangement and number of rows and the size of cob should be carefully considered. The ear should be well filled out at both ends; the rows should be straight and uniform; and the grains should be



A good stalk from which to select seed corn

wedge-shaped. These give the largest grain yield to the ear, and hence to the acre.



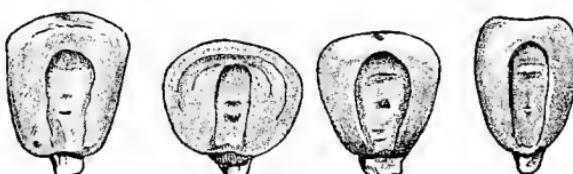
A bad ear of seed corn

Seed corn should be raised on a plot where it will not mix with other varieties. It should have fertile soil and careful cultivation. In thinning, all inferior plants should be destroyed. As the tassels appear, they should be removed from all barren, or earless, stalks. If these tassels are left, their pollen fertilizes the productive plants, and the number of barren stalks in the next crop is increased.

Wheat.—Wheat has been raised from very ancient times. The quantity and quality of the crop is highest in cool climates, but it will thrive in a variety of climates if given proper tillage and fertilizing. It prefers close, firm, rich land. A fertile loam is best, and next to that well-drained, manured clay. Sandy soils are poorest for wheat, because the subsoil is apt to be too open.

Wheat is raised in all sections of the United States. It is third in value of the crops of the country. The United States produces about one fifth of the three billion bushels which the world consumes annually.

The great wheat belt of America is in the Northwest, extending from Minnesota, North Dakota, and Montana northward far into Canada. This section is capable of producing the entire



Different shaped kernels of corn. The fourth is the best shaped. Why?

wheat supply of the world. Unfertilized, it averages twenty-four bushels to the acre.

The average production of the United States is only thirteen bushels, though forty is not an uncommon yield. The yield to the acre of the rocky New England farms is twice as large as the



SEEDING WHEAT AFTER CORN

fertile wheat lands of the West, because the eastern farmers prepare and fertilize the seed bed better.

Cultivation. — Thorough preparation of the soil is important for two reasons: it is a sowed crop, and all its cultivation must be given before it is seeded; it is a weak-feeding plant which has little power to get food for itself; it needs to have the soil fertile and mellow, — in condition to furnish it food.

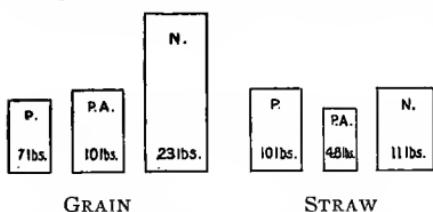
Wheat requires a firm seed bed to give root hold and to bring up water and food by capillarity. It needs, also, a fine, mellow

surface to favor germination and early growth. To secure this firm seed bed, the land should be plowed deep several weeks before seed time. To secure the fine surface, it should be harrowed repeatedly, so as to pulverize the two or three inches of top soil. The last working should be with the smoothing harrow, followed by the roller just before seeding the grain.

Seed can be sowed much more economically and evenly by the drill than by hand, and it is covered uniformly to the desired depth. Good seed on fertile, well-prepared land is apt to yield a bountiful harvest. Failure to produce good crops is usually due to poor, ill-prepared land and late plowing.

A field of ripening wheat, with its golden waves rippling in the breezes under the summer sunshine, is a beautiful sight. How the heart of the farmer is gladdened by a bountiful harvest as the reward of his labor! The ripe grain is cut and bound into bundles, called 'sheaves.' Formerly this had to be done by hand, but there are now labor-saving machines for the purpose. The sheaves are usually placed together in 'shocks' to dry. When dry, the wheat is threshed to separate the grain from the chaff and straw; the grain is sent to the mill to be ground into flour; the straw is

used for bedding or forage for stock.



This diagram shows the amount of fertility removed from an acre of soil by a crop of wheat yielding twenty bushels of grain and 2000 lbs. of straw.

Fertilizers. — Wheat needs to have the surface soil well supplied with plant food. It has no power to collect nitrogen for itself, and but small power to collect potash and phosphoric acid. Therefore

when these three elements are lacking in the soil, they must be supplied by well-rotted stable manure and by commercial ferti-

lizers. Lime is beneficial, making plant food in the soil available.

Place in Rotation.—One of the best and cheapest ways of fertilizing wheat is by preceding it with a nitrogen-collecting, deep-rooted crop, such as clover or cowpeas; this leaves the soil firm and the surface well supplied with plant food. After a legume, wheat needs potash and phosphoric acid. It is often sowed after tobacco to utilize the plant food which that leaves in the surface soil.

Wheat should be followed by a deep-rooted, strong-feeding crop. The worst crops to precede or follow it are other small grains and corn, which make practically the same demands on the soil.

Varicities.—There are hundreds of varieties of wheat developed chiefly by care, cultivation, and selection. A Pennsylvania farmer, passing one day through his field of bearded wheat, found a plant that was beardless. He saved the seed, and from that one plant was produced a productive beardless variety, of which thousands of bushels are grown every year.

Certain varieties have been brought from Russia which have



Courtesy of Ohio Agricultural Station

BEARDED AND BEARDED WHEAT

such power to resist drought that they extend the wheat-growing area hundreds of miles in the semi-arid states of the West and Southwest. Varieties have been bred which thrive on thin soils and in warm climates where wheat growing has hitherto been unprofitable. Many improved varieties are obtained by cross fertilizing by means of hand pollination, a process which has already been explained. The Minnesota Experiment Station has bred a variety that produces five bushels an acre more than any other variety grown in that section; this put millions of dollars into the pockets of farmers in the Northwest.

Wheat Breeding. — If you examine the wheat blossom, you will understand why cross fertilizing is rarely accomplished by nature. The head is made up of many separate flowers. Each flower has three stamens and one pistil, inclosed in a cover, or chaff, so

that the seed is self fertilized. A wheat breeder carefully removes the pollen from one flower and places it upon the pistil of another. Thus from two good plants, by repeated efforts, he may secure one better than either of its parents.



GOOD AND BAD SEED WHEAT

The grains at the left are plump and healthy; those on the right are shriveled.

After this wheat is threshed, it should be graded through sieves

Seed Selection. — The wheat crop can be greatly improved by careful selection of seed. A busy farmer is seldom able to select seed from individual plants, which is the way that many improved varieties are obtained. A seed strip, however, can be set aside in the best portion of the field.

in order to obtain the large, plump grains. The best of this should be used to sow a seed plot, and the remainder used for the field crop.

Any variety can be improved by raising seed every year in a plot given special care and preparation. The grain should always be graded, and the best used for the seed plot and the second best for the field crop. Small and inferior yields are often due to the use of poor seed, especially of inferior, shriveled spring grain for fall seeding.

Oats, Rye, and Barley. — Oats, rye, and barley resemble wheat in growth, but are stronger-feeding plants and flourish under less favorable conditions. They should be preceded or followed by deep-rooted plants, preferably by nitrogen-gathering ones.

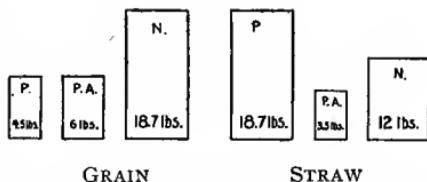
These small grains are cultivated in the United States for three purposes.

First: their grain crop makes wholesome and nourishing food for man and beast, and their straw is used for forage. Rye and barley are used in the manufacture of alcohol.

Second: these cereals make a good crop for green feed or for hay if cut just before they mature, when the stalks contain most nourishment.

Third: they are used as winter cover crops. For this purpose they are seeded in the fall; making their growth during the winter, they keep the land from washing and use plant food which would be wasted; they are then plowed under in the spring to supply the land with humus.

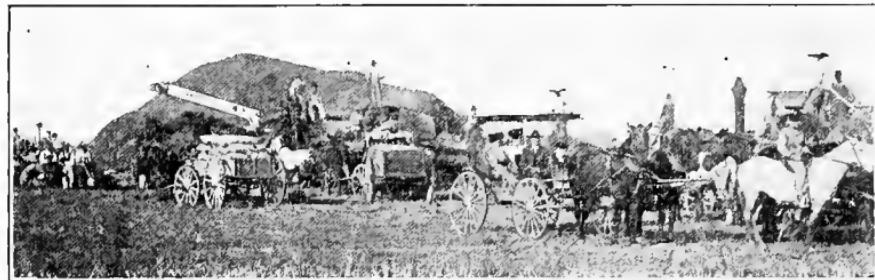
Rice. — Rice flourishes in warm climates and is raised in the



This diagram shows the amount of fertility removed from an acre of soil by a crop of oats yielding thirty bushels of grain and 2500 lbs. of straw.

southern states, especially those along the Gulf of Mexico. There are two distinct varieties: lowland rice, for which the fields have to be flooded at certain seasons, and upland rice, which is cultivated in practically the same way as other cereals, such as oats.

For lowland rice the land is prepared as for other grain, and the rice is sowed broadcast or put in drills and covered to a depth of about two inches. Then water is turned on from irrigating ditches



Courtesy of Arkansas Agricultural Station

THRESHING AND LOADING RICE

and is allowed to stand several days. It is then drawn off; after the plants get a good start, it is turned on again and is drawn off before harvest time. The crop is harvested and threshed very much like wheat.

The fact that the water needed is supplied by irrigation makes it practically a sure crop; and it is proving a profitable crop in Texas and Louisiana and other states where climate and moisture conditions are favorable.

EXERCISE

1. Plant grains of each of the cereals in a box with glass sides, as described in experiment 4 on page 72, and watch and compare the development of the plants.

2. Cultivate in carefully prepared plots each one of these six cereals that is adapted to your climate and conditions. Compare their habits

of growth and especially their seed heads. Select good varieties and try to make them better by good cultivation and careful seed selection.

3. Plant in one row small, shrunken grains of wheat and in the row next to it large, plump grains. Is there any difference in plants and yield in the two rows?

4. Obtain from your state Agricultural Experiment Station the score cards which it uses in judging corn, wheat, and other grains. Get from farmers or raise for yourself some of the varieties most popular in your neighborhood. Select five or ten of the best ears of each variety, and mark the points on a score card.

5. Select an ear of corn that has short grains and one of about the same size that has long wedge-shaped grains. Shell each and measure the grain to see which yields most. Weigh grain and cob of each separately. What per cent of each is corn and what per cent is cob? Good seed corn gives eighty-five per cent grain.

COTTON AND OTHER FIBER PLANTS

Fiber Materials. — There are four great staples which provide us materials for the fabrics which we use for so many purposes. Two of these, silk and wool, are animal products; two, cotton and flax, are vegetable ones. The United States imports three of these staples, silk, wool, and flax, usually manufactured into fabrics; the fourth, cotton, is our chief export and furnishes material for one of our most valuable manufacturing industries.

Uses of Cotton. — While the cotton plant is raised primarily for its fiber, other parts are useful, also. The seed furnishes an oil valuable for illuminating, cooking, and other purposes; the hulls and meal left from the manufacture of oil are used for stock feed and fertilizer. The root bark is used as a medicine, and the stalk fiber is woven into coarse cloth for bagging. Recently, machinery has been perfected to make paper out of the stalks;

this will doubtless increase the annual value of the crop about a hundred million dollars.

Range and Cultivation.—The cotton plant is of tropical origin, and its successful culture is limited to the region south of latitude



CHOPPING COTTON ON A PLANTATION IN LOUISIANA

thirty-seven. It needs a long growing season,—at least six months free from frost,—an abundant, even rainfall during its growing period, and much sunshine, especially during its ripening season.

Where climate and rainfall are favorable, it will thrive in almost any soil. It prefers, however, a medium loam.

After the plants come up, many good farmers run a harrow crosswise over the field, to destroy young weeds and to thin the cotton. The final thinning, or 'chopping to a stand,' should be done while the plants are small. If this be delayed too long, they become stunted and never regain their vitality. The cultivation should be clean and shallow, so as to destroy weeds and to

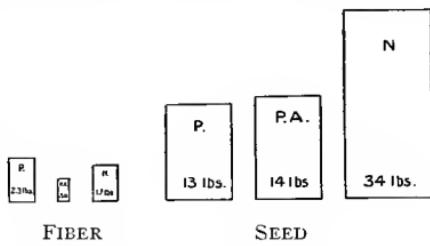
preserve a soil-mulch, but not to break the surface roots. It should not continue too late, else it will produce growth at expense of fruit.

The great labor of cotton production is picking the crop,—a tedious and costly operation which has to be performed by hand. Then the fiber is ginned to remove the seed, and the lint is pressed by machinery into large bundles, called 'bales,' each weighing about five hundred pounds. The baled cotton is sent to mills, where it is spun into thread and woven into cloth.

Cotton makes only moderate demands on the soil, but it is often profitable to use fertilizers to hasten its maturity. When plant food is scarce or unavailable, cotton needs to have supplied phosphoric acid, nitrogen, and potash. The cheapest way to furnish the nitrogen is usually to precede cotton with a nitrogen-gathering crop, such as cowpeas or crimson clover. If this is done, it will be necessary to furnish only the cheap mineral elements, phosphoric acid and potash.

Cotton lint is composed almost entirely of carbon, obtained from the air. If only this be removed, cotton takes less fertility from the land than almost any other crop. The seeds remove twenty-one times as much mineral matter as does the lint. They should be replaced by their equivalent in fertilizing elements. 'Replaced,' we say, for good farmers now seldom use cotton seed for a fertilizer, as they did some years ago, while poor ones left them to accumulate around the gin, like sawdust around a mill.

Now the seeds are usually sold to oil mills, which extract the oil.



This diagram shows the amount of potash, phosphoric acid, and nitrogen removed from an acre of soil by a crop of cotton, producing a bale of cotton and 1000 lb. of seed.

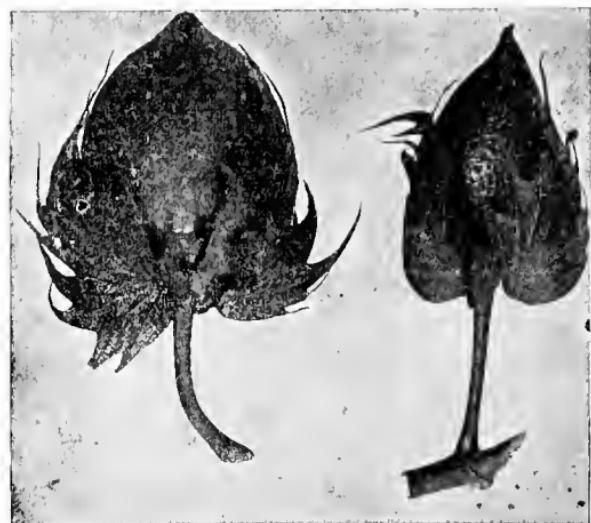
The hulls and meal left from the process are used as fertilizer or stock feed.

Place in Rotation.—Cotton, as already stated, removes from the land less fertility than almost any other crop. Why is it, then, that cotton farms are so often poor and 'run down'? This is due to unwise and improper cultivation. The one-crop system prevails largely throughout the cotton section. The same land is put in cotton year after year. Being a clean crop, it destroys

humus. Being gathered late, it often leaves the land bare through the winter to lose more by leaching and washing than by its summer crop.

Cotton should take its place in a regular rotation and should stay there. In this rotation there should be a nitrogen-gathering, humus-producing crop.

Crimson clover

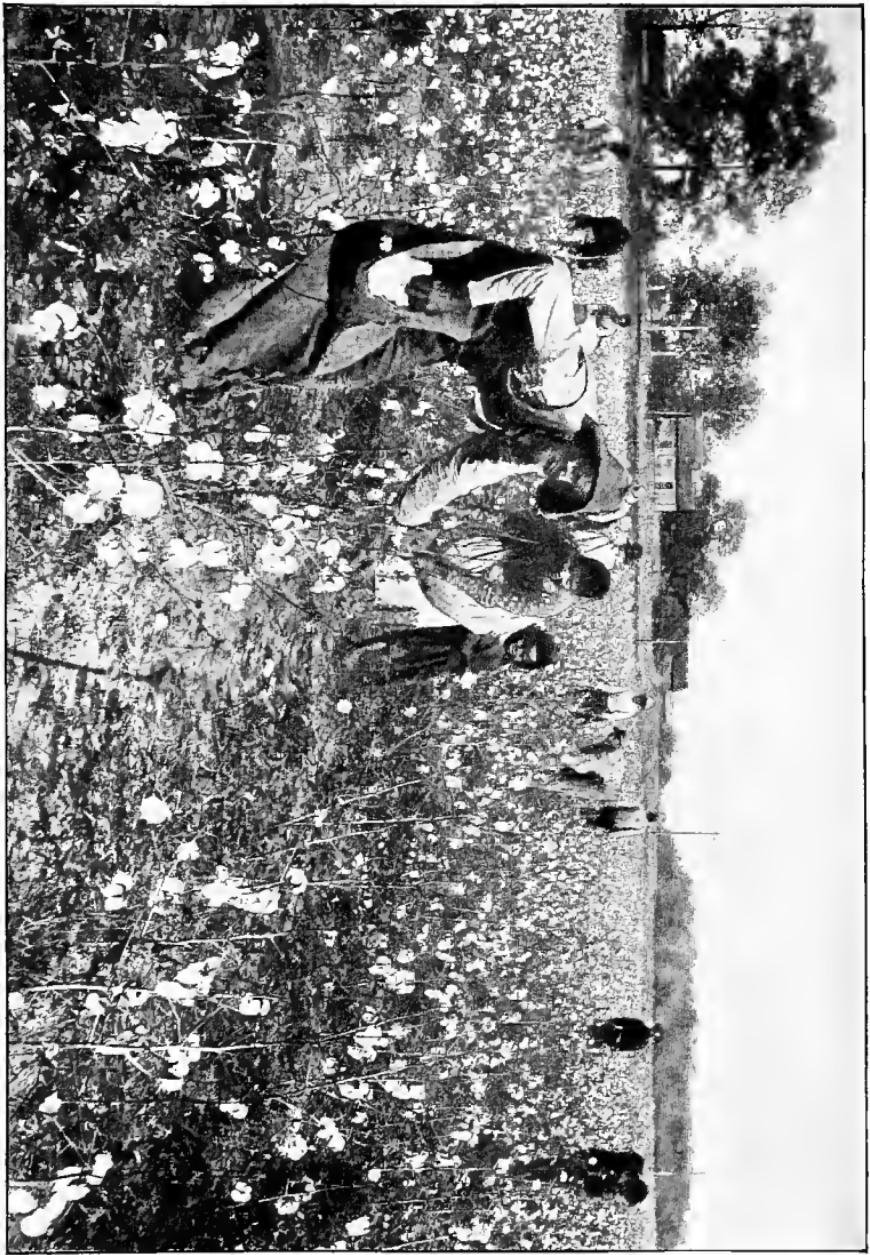


COTTON BOLLS

On the left is American upland; on the right, sea island.

should be sowed in cotton, at the last working, or rye, after it is gathered, to furnish a winter cover-crop.

Sea Island and Upland Cotton.—There are two kinds of cotton raised in the United States, sea island and upland. The sea island cotton flourishes on the islands and along the coast of South Carolina, Georgia, and Florida. It needs a hot, humid climate.



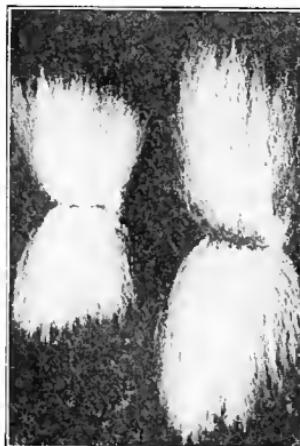
PICKING COTTON ON A SOUTHERN PLANTATION

Its long, beautiful, silky staple, or fiber, is much valued for making lace and thread. The yield is smaller than that of the short-stapled upland varieties which are cultivated in most of the cotton belt.

Wilt and Weevils. — Within recent years the cotton crop in some sections has suffered much from disease and insect ravages. The sea island cotton was attacked by a wilt disease which destroyed entire crops; cotton grown on the same land for years afterward was almost sure to be attacked by this deadly leaf wilt. By careful selection of resistant plants, a wilt-resisting variety was bred. The upland cotton in Texas was attacked by the Mexican boll weevil, which is gradually infesting the cotton-growing region. You will learn more about this insect in the chapter on *Crop Enemies*. Although it has done great damage, the boll weevil has been of some use, as it is causing southern farmers to improve their cultural methods.

Seed Selection. — Plants for seed should be selected with care in the field, and marked before picking begins. They should be thrifty, free from disease, and should have many and large bolls. The fiber should be long rather than short. The selected seed should be planted in a separate plot and carefully tended. From the best plants seed should be saved for next year's seed plot, and from the others seed for the field crop. No seed 'runs out' more quickly than cotton where careful selection is not practiced.

Flax. — Flax is another valuable fiber plant. The long, fine, tough fibers of its stem are used for making linen. Flax seed, or



Staple, or fiber, showing difference in length between upland and sea island cotton.



Courtesy of North Dakota Agricultural Station

PULLING AND SORTING FLAX IN BELGIUM

linseed as its seed are often called, are, like cotton seed, rich in oil. This linseed oil is used for mixing paints and varnishes and for other purposes. The hulls and meal from which the oil has been extracted are a valuable stock feed, rich in fertilizing elements.

Cultivation.—Flax prefers a cool, moist climate. It thrives on a deep, well-cultivated loam. It grows to a height of two or three feet, bearing clusters of pretty blue or white flowers at the ends of the branches. The best fiber is obtained from the stalks of plants that are grown close together and are pulled soon after blossoming. Usually, however, they are sowed thinner and are allowed to ripen seed for oil.

Like cotton, the flax crop has been threatened by wilt disease, but of this also a wilt-resisting variety has been bred.

Hemp.—Hemp, like flax, flourishes on a moist, fertile soil. If the soil be rich and the weather moist and warm, the plants grow rapidly and form long fibers. Stunted plants produce short, inferior fiber. The fiber, the cells of its inner bark, is coarser than flax; it is used to make coarse cloth and rope.

EXERCISE

1. Grow cotton, flax, and hemp in well-cultivated plots.
2. Sow some of the flax thick and some thin. Observe the difference in branching and flowering.
3. Separate and examine the flax and the hemp fiber. Compare them with cotton.



A, flax fiber; *B*, hemp fiber

TOBACCO

The Tobacco Plant. — America has contributed few agricultural plants to the world. Among these are the white potato, the sweet potato, corn, and tobacco. Potatoes and corn are useful foods; the tobacco is not a food plant.

Uses. — The leaves are used for chewing and smoking. They contain a stimulating compound called nicotine. In its pure condition nicotine is a poison, and every man who uses tobacco takes into his system more or less of this poison.

History. — The Indians raised little patches of tobacco and used the pipe for private comfort and public ceremony. In the sixteenth century, the weed was introduced into Europe and its use became a fashion and a habit. Cultivating the crop for the European market was one of the first American agricultural industries. The estates on which it was cultivated were called 'plantations' because, instead of being raised like most agricultural crops, the seeds were raised in a seed bed and the young plants set in the field.

Range. — Tobacco grows from the equator to Canada. It is raised chiefly in the eastern part of the United States, but is successfully grown on the irrigated lands of the West. Its quality depends largely on the amount and season of water supply, and where this is regulated by irrigation, tobacco proves a sure and profitable crop.

Soil and Climate. — No other field crop is so much affected by conditions of soil. A variety changes its character entirely on different soils. On a fertile clay, it may produce large, heavy plants with leaves rich in oil or gum, which cure dark red or brown. On a light, sandy soil, this same variety will produce

thin leaves of fine texture, which cure yellow or mahogany color. Bright tobacco cannot be raised on clay, nor heavy tobacco on sandy land.

The farmer must consider his soil and climate, and must grow the variety to which these are adapted. While the type of tobacco depends upon soil and climate, the grade depends upon cultivation, fertilizing, and curing.



CUTTING TOBACCO

Cost. — The raising of the crop requires skill and experience and prompt attention to every detail. The rewards of success are large, but the risks are many and the cost of producing the crop is great. Tobacco is an expensive crop in several ways; it costs the farmer much labor, it costs the farm much fertility,— and if weather conditions be unfavorable, in spite of labor and fertility the crop is a failure.

Cultivation. — Tobacco plants are grown in a carefully prepared seed-bed, often under cover to protect them from frost and insects.

The land for the crop is plowed deep, harrowed fine, and well supplied with plant food.

The plants must be transplanted, preferably when the weather is moist and cloudy, and given frequent shallow cultivation to

keep the soil free from weeds and in good condition. They must be protected against worms by poison or by picking. They are 'topped,' — that is, the main stem is broken off, leaving a certain number of leaves, — to make the leaves as even in size and quality and time of ripening as possible.

This diagram shows the amount of fertility removed from an acre of soil by a crop of tobacco producing 1000 lbs. of leaves and 1750 lbs. of stalks.

After the plant is topped, in its efforts to continue its growth it throws out 'suckers,' or shoots, from the joints of the stem;



TOBACCO SEEDLINGS FROM LIGHT, MEDIUM, AND HEAVY SEED

these must be kept pinched off so as not to lessen the leaves' supply of food.

Slight changes in color and texture indicate to the experienced hand and eye when the plants are ripe. The leaves are then pulled or the plants cut, and they are cured,—often by carefully regulated artificial heat. The curing, sorting, and handling of the crop are operations that require skill, practice, and much labor.

Fertilizers.—Tobacco is a greedy feeder which requires large quantities of food, especially of nitrogen and potash. For heavy tobacco, these are supplied largely by stable manure and by general enrichment of the soil. For bright tobacco, commercial fertilizers are generally used to give the leaf the desired color and texture. Crop rotation, manures, and legumes are necessary to keep up the fertility of the soil.

Place in Rotation.—As tobacco is such a large consumer of plant food, it should be preceded or followed by a nitrogen-gathering crop, such as cowpeas or clover. It is often followed by wheat or other small grain that uses the plant food which it leaves in the surface soil.

Seed Selection.—The seed plants should be carefully selected and should be those which come nearest the farmer's ideal of what he would like every plant to be. They should be healthy plants with well-shaped leaves, and as free from suckers as possible. Just before it blooms, the flower head should be inclosed in a paper bag, in order to prevent its receiving pollen from inferior plants.

The seed should be graded, so as to separate the different sizes and weights. Large and heavy seeds produce strong and



TOBACCO PLANT

Bagged for seed

vigorous plants. By careful field selection of seed every year, a farmer can grade up and improve the quality and yield of a variety.

EXERCISE

1. Raise several plants of tobacco, trying to give them as favorable conditions as possible. Leave one or two of the best plants to mature seed.
2. Top the other plants at different heights, leaving from eight to fourteen leaves. What difference does this make in the leaves?
3. Pull and dry the leaves. Take an equal weight of tobacco leaves and of dry fodder and burn both. What difference is there in the way they burn? It is the large amount of potash in the tobacco which causes it to burn so readily. Compare the amount of ash left by the tobacco leaves and by the fodder. Can you account for the difference?

SUGAR-PRODUCING PLANTS

There are two great sugar-producing crops that are raised in the United States, — sugar cane in the South and sugar beets in the North.

Sugar Cane. — Sugar cane is a tropical member of the grass family. It is cultivated for the sweet juice laid up in the cells of its stalk. Sirup, molasses, and sugar are made from this juice. Sugar cane is extensively grown in the South, especially in the Gulf States.

It is a perennial, reproduced by cuttings, which are pieces of the stalk containing 'eyes,' or buds. Generally, two or three crops are grown from a planting. In spring or fall the stalk cuttings are buried in furrows. They soon begin to send up sprouts. The crop is cultivated like corn. Like corn, it requires a fertile soil

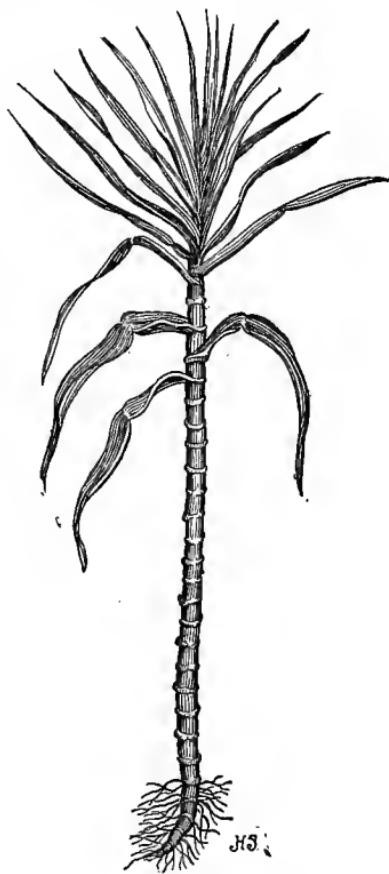
and it requires a great deal of water. If water and plant food be supplied, it will thrive on any well-drained soil.

The stalks are cut in the fall, and crushed in mills. The juice is boiled and evaporated to form a sirup. There are several different methods of evaporating this juice so as to separate it into sugar and molasses.

Sorghum.—Sorghum is another member of the grass family which has a sweet juice in its cells. Sorghum thrives where it is too cool and too dry for sugar cane. Its juice is extracted and boiled down to form sirup or molasses. By selection of seed from plants rich in sugar, the per cent of sugar has been largely increased.

Sugar Beets.—The sugar beet industry was developed in Europe by selecting and cultivating beets so as to increase the quantity of sugar they contain. Small pieces of the roots were tested, and those having the largest amount of sugar were planted for seed. Thus the quantity of sugar has been increased from eight to eighteen per cent. Roots have been raised of which twenty-five per cent, one fourth of the whole, was pure sugar.

Within recent years the sugar beet industry has been introduced into the United States. A section of the northern part of the



SUGAR CANE

country, from the Pacific to the Atlantic, is well adapted to the crop. The soil must be fertile, well drained, and well cultivated.



A sugar beet root which tested 24 per cent sugar. An acre of such beets would yield 42,000 lb. of sugar.

The mature beets are dug and sent to the factory. There they are cleaned, the juice extracted, and the sugar obtained from it by evaporation.

Sugar, like cotton, is formed from the carbon of the air; therefore, if the leaves and pulp be returned to the fields or used for stock feed and the manure put on the land, the crop removes little fertility from the soil.

EXERCISE

1. Cultivate some specimens of the crop plants mentioned here. Where the climate is too cool for sugar cane, sorghum may thrive.

2. Compare the sweetness of cane cut from green plants, from those just about to flower, and from those that have gone to seed.

THE ORCHARD AND ITS CARE

Our common fruits — apple, pear, quince, peach, plum, apricot, and cherry — all belong to the rose family; so do the strawberry, raspberry, and blackberry. The orange, lemon,

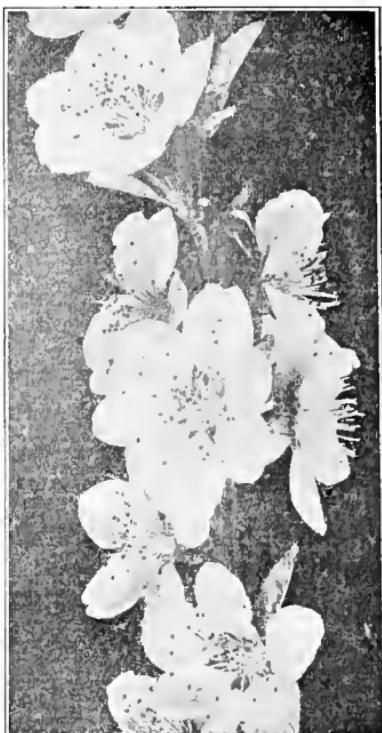
and lime belong to the citrus family, which is a native of Asia.

The Apple.—The apple is more widely grown in the United States than any other fruit. Like the Caucasian race, it is not a native of America, but finds here a congenial home. It thrives in all sections and on almost all soils. There are hundreds of varieties, differing in flavor, appearance, and ripening season. By selecting summer, fall, and winter apples adapted to his locality, every farmer can have the fresh fruit throughout the year.

The Pear.—There are two groups of pears cultivated in the United States. The European varieties, derived from the native pear of Europe, are the better flavored; the Oriental ones, derived from the native pear of China and Japan, are vigorous growers and productive, but are usually inferior in quality of fruit. The Bartlett and Seckel are European pears, the Kieffer is an Oriental one.

Standard pears are those grafted or budded on pear roots; dwarfs are those grown on quince roots; they are smaller and come into bearing earlier.

The Peach.—Break open a peach stone and notice how much the seed resembles an almond. The two are closely related, and



Courtesy of Delaware Agricultural Station

BLOSSOMS OF CHINESE CLING PEACH

both are natives of the Old World. The peach thrives best in a sandy soil. It does well on a clay soil, however, if it be well drained. Peach trees come into bearing early and are short-lived. They are often planted between apple trees in an orchard; they mature and can be cut out before the apple trees begin to bear.

The Cherry. — The cherry, like the peach, prefers a light soil. There are many varieties of wild cherries in America, but most of our cultivated cherries are derived from two European varieties, the hearts and the mo rĕl los. The morellas, which are sour, are the hardier.

The Plum. — Plums prefer a clay soil. Those grown on peach roots, however, thrive on sandy soils. The gage and other European varieties thrive in the northern states; the Japanese ones are better adapted to the South; in the Northwest only the native American plums are hardy.

The Lemon, Orange, and Citrange. — Oranges and lemons are tender tropical trees. They are grown in our southern states, but even in Florida the weather is sometimes severe enough to injure or even to destroy them.

Scientists are trying to breed hardy fruits of this family, and doubtless they will succeed. A new fruit, the cit range', has been created by crossing the little hardy Japanese orange with the Florida orange. The citrange is so acid that it resembles the lemon more than the orange; it is quite hardy in the Gulf and South Atlantic states.

How Fruit Trees are Raised. — If you wish a crop of a certain kind of corn, you plant seed of that variety. But this is not the way in which you get a desired variety of apples or pears. Their seed do not 'come true,' as farmers say. Seedlings, or trees from seeds, instead of resembling their parents, may be like the wild fruits from which they originated. You may plant seed from a

large, sweet, red apple and raise a tree bearing small, sour, green fruit.

Most fruit trees are grown by budding, a method which has already been mentioned. The process requires considerable care and skill. Farmers usually prefer to leave it to professional fruit-growers and to buy trees ready for planting. How does the fruit-grower raise a tree? Take an apple, for instance.

The seeds are planted in the spring. The little seedling is grafted the next winter or budded the following summer with a graft or bud of the desired variety.

Grafting. — Grafting is done during the dormant season when the tree is not growing. The top of the seedling, or 'stock' as it is called in grafting, is cut off. The 'scion,' which is a straight vigorous twig of last year's growth of the desired variety, is cut so as to fit the stock as closely as possible. The cambium of one must touch that of the other, for this is the living part of the tree and through it the sap must pass from one to the other. If the cambiums do not unite, the scion dies for lack of nourishment. The joining of the scion and stock must be air-tight; it is covered with grafting wax, made of beeswax, tallow, and linseed oil. Then the graft is wrapped to hold the scion firmly in place.

Budding. — Budding is sometimes preferred to grafting. Budding is done in the summer during the growing season. A bud from the desired variety is inserted into a T-shaped cut in the bark of the stock or seedling. The joining is covered with wax and wrapped to exclude the air and to hold the bud in place. The next spring this wrapping is removed. The top of the stock is cut off so as to throw sap and growth into the bud shoot.

Transplanting. — The grafted or budded tree is left to grow one or two or more years. Then it is set out in the orchard. It is called one or two or three years old, according to the age of the

bud or graft. The root is a year older. A vigorous tree, one or two years old, is generally better than one of more advanced age. The larger the tree, the more difficult it is to transplant it without injury to the root system.

Twig Budding or Grafting. — By budding or grafting its branches, we can have many varieties on a tree. One apple tree may bear



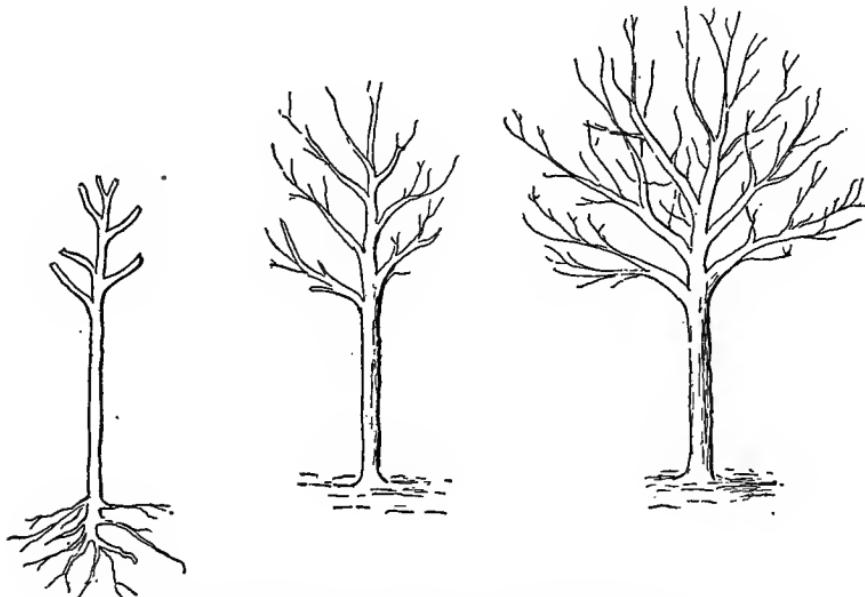
THE COURSE OF FAILURE THROUGH FIVE YEARS

This tree is improperly set, unpruned, uncultivated, and neglected; it grows slowly, is badly-shaped and diseased.

summer and fall and winter varieties; there are grafted trees which yield hundreds of different kinds. Perhaps, if you experiment carefully, you may succeed in grafting a branch. Grafting is generally used for apples and pears, but budding is preferred for plums and peaches.

Orchard Location. — The location of an orchard is a matter of importance. It is not planted for one season or one crop, but for ten or twenty or more. It is usually desirable to have an orchard, especially a small one, near the dwelling house. Orchards on

elevated rolling land are less apt to be injured by frost than those on lowlands where air does not circulate so freely. Most fruit trees prefer a fairly fertile clay loam. Orchards, like other crops,



THE COURSE OF SUCCESS THROUGH FIVE YEARS

This tree is properly planted, properly pruned, and cultivated; it grows fast and yields early and well.

do not thrive and give good results on poor soil. The land must be well drained, either naturally or artificially.

Selection of Varieties. — Varieties should be selected which are adapted to the soil and climate and to the purpose in view. Some varieties are good in one section and poor in another. An instance of this is the Albemarle or Newtown pippin. It is the finest and best-flavored of apples when grown in a limited section of Virginia, North Carolina, and California; out of this section it is an ordinary and rather insipid fruit.

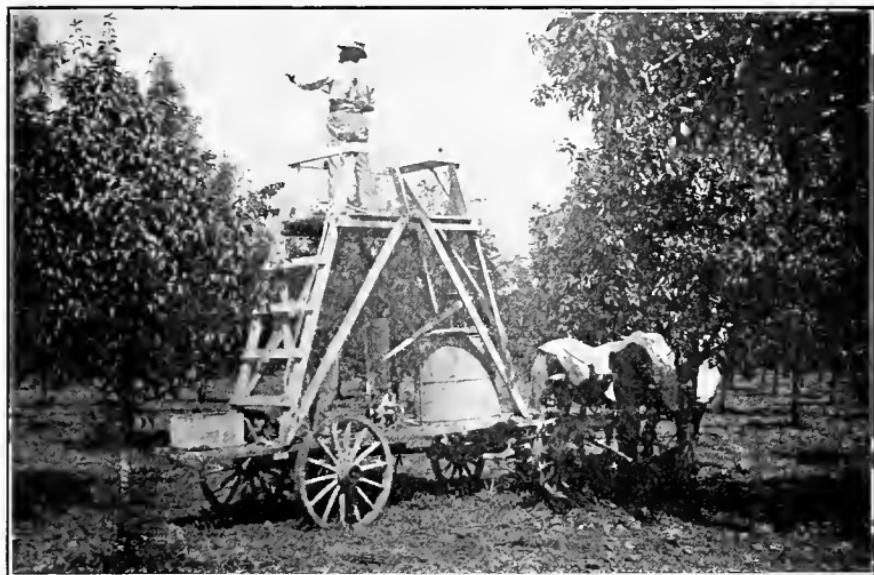
A small orchard for home use should have varieties which give a succession of fruit throughout the season. The varieties in a market orchard should be the most salable ones adapted to the section. Near a good market, summer and fall fruits are often profitable. At a distance from market, varieties that keep well and bear handling and storage should be raised.

Transplanting Trees. — Young fruit trees can be set out in fall or spring; spring planting is usually preferred. On page 63 there are general suggestions for transplanting, but there are some special points which should be regarded in the case of trees. A portion of the soil should be dug away, and the roots should be loosened and carefully withdrawn. Bruised and broken roots should be trimmed off. In resetting it, the subsoil should be loosened at the bottom of the hole, and a little fine soil put in. Then the tree should be set with its largest root in the direction of the prevailing wind.

Orchard Cultivation. — After the young orchard is set, it should be cultivated. No farmer expects to make a crop of corn or tobacco without care and tillage. Without care and tillage, it is just as impossible to raise good orchard crops. It is money and time wasted to buy and transplant trees and then neglect them.

The orchard should not be used as a grain field nor a pasture. This does not mean that crops, often profitable ones, cannot be raised in an orchard. But the trees must be the first consideration. Stock, especially cattle, should never be kept in a young orchard, as they injure and often kill the trees. Small grain should never be grown in it; grain and trees make growth and require much moisture at the same time, and the trees are robbed of food and moisture. Clean crops which destroy humus should be followed by cover or catch crops cut for hay or plowed under in the early spring.

Care should be taken that neither teams nor tools break or scar the trees, and that the plow does not go close and deep enough to break their roots. After a few years the orchard may be 'put down' in grass, such as blue grass or orchard grass, though



SPRAYING FRUIT TREES

a compact sod should not be allowed to form around the trees.

Fertilizers. — The best fertilizers for fruits are those containing potash which improves the quality of the fruit. There is no better fertilizer than wood ashes.

Spraying. — Trees sometimes need medicine as well as food. Fungous diseases and insects often attack fruit trees and, if unchecked, cause death. Some of these diseases are very contagious and widespread. It requires care and watchfulness to keep them

in check. In the chapter on *Crop Enemies* you are told about some of these pests and the best methods of controlling them.

It is as important to destroy these enemies when there is no crop as when there is a heavy one. They injure the trees and lessen future crops. Fruit buds are formed one season for the next, and the tree needs to be in a healthy, vigorous condition to store up material and to provide for the next crop.



The top branch on the left is properly cut, and that on the right is improperly cut; observe the difference in the healing of the two. The lower left-hand branch is sawed from the top, and its weight causes it to fall and split the tree; this is prevented in the case of the right-hand branch by first making an incision in the lower side.

keep the ground moist. It is less troublesome to prune and spray them and to gather the fruit.

Thinning.—Where there is a heavy crop, it is well to thin it by removing some of the fruit while small. If all be left, it is likely to split or break the trees. Moreover, the trees are often so exhausted by fruiting a large crop one year that they form few fruit buds, and the next season yield little or nothing. A moderate crop every year is better for the trees and better for the farmer.

Pruning.—Experience has shown that there are better results where tree growth is trained. Hence, training or pruning has become an important part of orchard work.

The orchardist should decide what shape he wishes his trees to have and prune them accordingly. When trees are pruned so as to give a low, spreading growth, they suffer less from wind and from drought, because the low branches

Growth should be directed as much as possible by rubbing off buds and cutting off twigs that interlap and grow toward the center. This will prevent the necessity of cutting large branches later, will keep the center open to air and sunlight, and will lighten the labor of spraying and of fruit-gathering. Except in old, neglected orchards, severe pruning is rarely necessary. When a large branch is cut, a clean, close cut should be made so that it will heal without leaving a stump. The wound should be painted with white lead to prevent rotting.

Pruning in winter increases the yield of fruit, in summer increases the growth of wood. The worst time for pruning is in the spring when the buds begin to start. Wounds made then are slow to heal.

EXERCISE

1. You will find it interesting to try to bud and graft some fruit trees. Unless you are careful about every detail, your buds and grafts will not live.
2. Transplant and raise one or more fruit trees, observing the suggestions on pages 63 and 172.
3. Compare the blossoms and leaves of the different fruit trees of your section.
4. Compare ripe fruits in order to see what forms the edible portion. Take two apples and two pears. Cut one of each lengthwise and one crosswise. The edible portion is the thickened lower part of the calyx and the enlarged stem. Take some stone fruits — the peach, plum, and cherry — and examine their parts. The edible portion is the soft juicy part of the calyx leaves. The seed or true fruit is inclosed in the stone in the center of what we call the fruit. Can you think of any reason why these seeds are not edible and the seed covering is?
5. Prune a tree by cutting off two small branches that interlap or grow toward the center. Cut one branch close to the tree trunk, and leave the other two or three inches long. What difference is there in the way that they heal?

THE VEGETABLE GARDEN

Value of Farm Garden. — The farm garden should always be one of the first considerations. It provides for the table, and perhaps for market also, the vegetables and small fruits which those who live in cities have to obtain at much greater expense from the market and green grocery.

The garden should be plowed and planted at the proper time,



HAND WEEDER

and tilled so as to produce the best results. It should furnish a succession of seasonable vegetables, supplying wholesome and palatable food. In

no other way can the same outlay of time, labor, and money give greater returns.

Location and Cultivation. — The garden should be convenient to the house. It is better to have the beds long and narrow, rather than short and broad; thus more work can be done by horse and by wheel tools. By frequent cultivation under proper conditions, its soil should be made a fine deep seed-bed. It should be thoroughly fertilized. For most vegetables the soil cannot be too rich; usually, the more rapid their growth, the better their texture and flavor.

No untilled corners nor hedgerows should be left in a garden to shelter and breed weeds and insect pests. Nor should the soil be left idle to waste plant food, grow up in weeds, and infest the land with weed seeds. As soon as early vegetables are gathered, their rows or plots should be planted in late ones or seeded in some crop, such as clover or rye, to turn under in the spring.



WEEDING OR THINNING HOOK

In the garden, as in the field, rotation of crops should be practiced. Diseases are increased and insect pests harbored by having the same crop in the same place year after year.

Truck Farming. — Truck farming, or market gardening, is an important and, in many localities, a profitable branch of farming. Earliness and productiveness are the qualities most sought for its products. The soil must be a light, warm one that will produce early crops; by liberal use of stable manure and commercial fertilizers, it can be made productive.

The great market garden of the United States is a narrow strip extending fifteen hundred miles along the Atlantic Coast. This coast region is free from late frosts in spring and early ones in fall. The soil is light, warm, and sandy; it is made very fertile with manures and fertilizers. There is a similar soil on the Pacific Coast.

Surplus Products. — There is a frequent and direct loss of truck products through inability to market them promptly and profitably. The farmer may be unable to secure transportation or his products may come in when the market is glutted. There are always some unsalable inferior fruits and vegetables. Sometimes the year's balance is changed from loss to profit by putting these surplus products into salable forms instead of leaving them to rot in the field.

In canneries many perishable products may be put in shape to be stored and held for market. Fruit may be dried, or evaporated, — that is, dried by artificial heat — or the juice may be extracted and sold as cider or vinegar. Surplus fruit, melons, and vegetables may be utilized by feeding them to stock.

Root Crops. — Root crops make their growth underground. Some of these, such as the sweet potato, are enlarged fibrous roots; some, such as the turnip, are enlarged taproots; others, such as the white potato, are not roots, but tubers, or enlarged underground

stems; bulbs, such as the onion, are thickened underground leaves. All these crops need a mellow, fertile soil that can be pushed aside

by the growing root, tuber, or bulb, and that supplies food elements fully and freely.

Where the soil is not naturally loose and porous, it should be plowed deep and made fine and mellow. On heavy soils ridge cultivation may be better; on light soils level cultivation lessens the evils of drought and promotes the use of cultivating tools. The crops for winter keeping should be harvested in dry weather. They should be kept in a cool, dark, well-drained, well-ventilated place.

Turnips, *ru'ta-bā'gas*, *mān'gel-wür'zels*, sugar beets, and carrots

Potato plant, showing root system and growth of tubers.

are raised in some sections as field crops for stock feed in winter. They are often sowed on wheat or oat stubble. English farmers say that their breeds of cattle and sheep have greatly improved since root crops are raised and fed. These crops are being more and more largely grown in the United States.

Potatoes. — Potatoes, sweet and white, are the vegetables most widely raised for table use. Sweet potatoes require a long growing season and so thrive best in the South; they prefer a porous, sandy soil.

The white potato is raised in all sections of the United States. It is a greedy feeder, and thrives best in a fertile, deep, well-drained



loam. Seed should be selected from plants bearing a large number of good-sized, well-shaped potatoes.

Onions.—Millions of bushels of onions are imported to the United States every year; they might be raised at home, putting millions of dollars into the pockets of American farmers. Onions are grown from seeds or from sets. Cheaper, better, and earlier onions are grown by raising plants from seeds in seed beds or hotbeds and transplanting them.

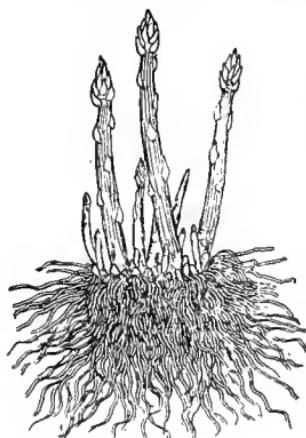
Tomato.—The tomato has a trailing stem and needs to be trained to a trellis or stake. Sometimes the branches are pinched off and the main stem is tied to a support and has its bud pinched off at a height of about four feet. Thus trained, it gives better results in hot, dry weather, and yields several clusters of large, perfect fruit.

Celery.—Celery is a popular vegetable, and is not difficult to grow, though most home gardeners suppose that it is. The plants are grown from seed in a hotbed and then transplanted to a fertile spot. They must be well watered and well cultivated. Instead of heaping up



TOMATO PLANT TRAINED TO THREE STEMS

a bank of earth to blanch, or whiten, celery, a board can be set on each side of the row so as to keep out the sunlight.



ASPARAGUS PLANT

Asparagus.—Asparagus is another popular but little raised vegetable. Beds once established last a long time. Asparagus should not be cut until the plants have been three years set.

Legumes.—Peas, string beans, or snaps, and the shell beans, lima, navy, and butter beans, are legumes. These require a fairly fertile soil; if they are given other plant food, the summer-growing ones get their nitrogen from the air.

Melon Family.—To the melon family belong muskmelon, watermelon, cucumber, squash or cymling, and pumpkin. Different as these seem, they are alike in many ways. Most of them are tropical or sub-tropical plants and very tender; they must not be planted until danger of frost is over and the ground is warm. They need light, mellow, well-drained soil. If planted near one another, members of this family mix. They all have some very troublesome insect enemies, beetles and bugs.

Sweet Corn.—Sweet corn requires the same cultivation and care as does field corn, which has been described. It should never be near enough to mix with the field varieties.

Okra, Cabbage.—Okra is grown in hot, dry sections, but does not thrive in cool, moist ones; cabbage, on the other hand, heads better in a cool climate.

Herbs.—In every country garden there should be an herb bed for seasoning and flavors. Here should grow such herbs as sage, lavender, spearmint, thyme, mär'jo ram, and sā'vo ry. Sweet

herbs give best results in a moderately fertile place; on very rich soil, the oil supply is small. In order to develop their oil, herbs need a sunny exposure.

Small Fruits.—Nor is the country garden complete without some berries, bush fruits, and grapevines. These should not be planted



A FIELD OF PUMPKINS

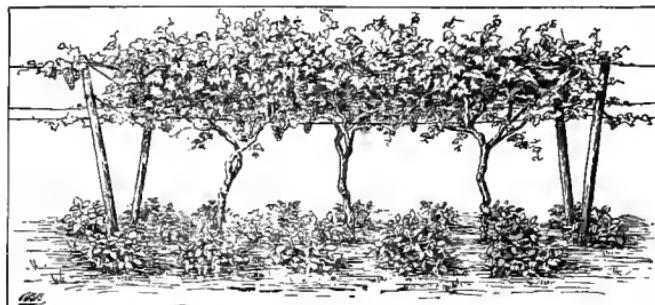
along fences and in corners. They should be set where they can be well cultivated. They need air, sunlight, and good culture.

Raspberries.—Raspberries prefer a fertile, rather moist loam. In warm climates they thrive better when sheltered from the midday and afternoon sun. Canes that put forth one spring bear fruit the second summer. After bearing one crop, they die and new ones grow from the roots. The old canes should be cut in fall or early spring. Annual prunings, clean cultivation, and an occasional

mulch of coarse manure will secure the best results of which a variety is capable.

Blackberries. — Blackberries require practically the same cultivation as raspberries. The cultivated varieties are more productive than the wild ones.

Strawberries. — Strawberries are greedy feeders and it is impossible to make the soil too rich for



STRAWBERRIES UNDER GRAPEVINES

them. Wood ashes is an excellent fertilizer, as it increases both the quantity and the quality of the yield. Berries grown on a sandy soil are firmer and better-colored than those grown on clay soil.

Among the best-bearing varieties are those that have imperfect, pistil-bearing blossoms. To secure a good yield, these must be grown near plants with perfect blossoms. Usually the bed is plowed up the second or third year and a new one set.

Bush Fruits. — The most generally cultivated bush fruits are the currant and gooseberry. They prefer a cool, moist soil; currants especially are not grown successfully in the South. The English gooseberries are large and well-flavored, but are subject to disease. In many sections native varieties of gooseberries, plums, and grapes grow well, while foreign varieties do not thrive.

Grapes. — Grapes belong to the vine family. Most of the grapes raised in the United States, such as the Catawba and the Concord, have been developed from native wild varieties. The wine and

table grapes, which are natives of Europe and Asia, are successfully raised in California and in sections of the South.

Grapes thrive best in warm, fertile soil, with sunny exposure. They are grown from cuttings and layers. The vines are trained to trellises or stakes, and should be well pruned during the dormant season. It should be remembered that "fruit forms upon shoots that grow this year from eyes that were formed on the wood that grew last year."

After the harvest is over, grapevines should not be neglected, left to be choked with weeds and injured by fungous growth. They need to be kept thrifty and vigorous so as to mature new wood and develop healthy buds for next season's growth.



Courtesy of New Mexico Agricultural Station

GRAPES

EXERCISE

1. Raise on well-prepared, well-cultivated plots the vegetables which succeed best in your locality. Select good varieties and try to improve them. How can you do this?
2. Compare the parts of different plants which make their growth underground,— such as a sweet potato, a turnip, a white potato, and an onion.

3. Grow some beets in mellow, well-drained soil, and some of the same variety in a hard, cloddy clay. Is there any difference in their appearance?

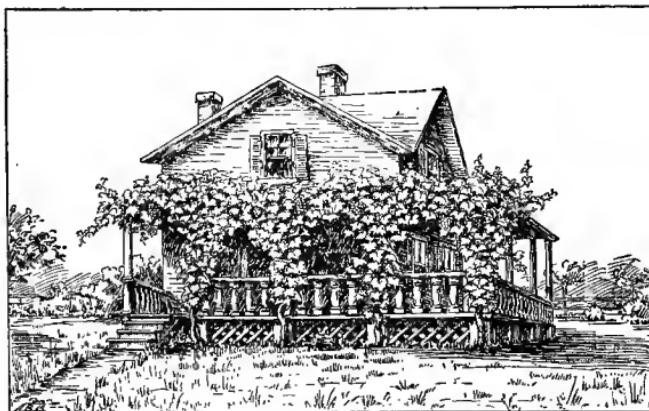
4. Leave where they grew the stalks of some corn and the tops of some white potatoes. In three or four weeks compare what is left of them. What has become of the potato tops? Can you think of any reason for this?

5. Why do you plant beans and peas shallower than corn? Can you explain why the young peas and beans grow so much more rapidly than tomatoes and onions started from seed?

6. Some of our common vegetables, such as cabbage, tomato, and sweet potato, are of tropical origin. To give them a longer growing season, start these plants in seed beds, or hotbeds which have a layer of manure under the soil, and transplant them to the garden.

7. You will enjoy raising some berries and grapevines for yourself. They are not much trouble, and give large returns in luscious fruit.

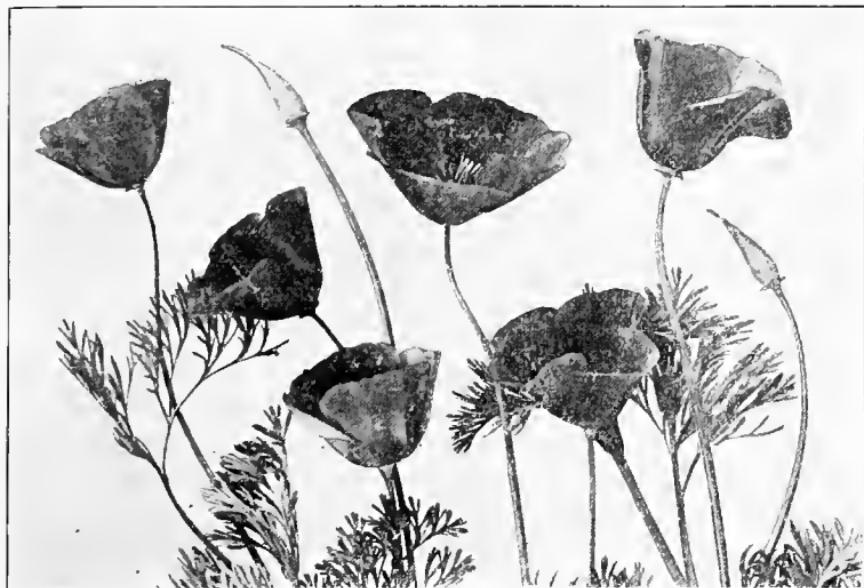
THE FLOWER GARDEN



A VINE-CLAD PORCH

Flowers. — We are not satisfied with merely useful things. We desire beautiful ones. It is not enough for us that our earth brings forth corn and potatoes. We want, we need, flowers, beautiful of color, graceful of form, fragrant of scent. Around and in the house they are a constant source of pleasure.

Selection.—Our cultivated flowers, like our agricultural plants, have been produced from wild ones. They have been selected for beauty as the vegetables have been chosen for use. In many cases our flowers and crop plants are very closely related. The hollyhock is near kin to the cotton. Its large, many-colored, double flowers are the result of long-continued selection and reselection.

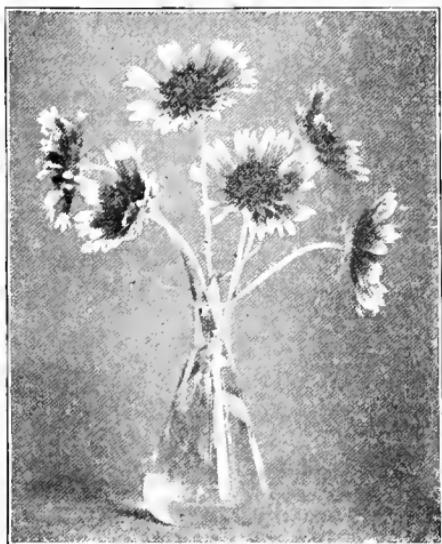


Courtesy of Messrs. Burpee & Co.

CRIMSON CALIFORNIA POPPIES

The Crimson California Poppy.—An instance will show you how this is done. Mr. Luther Burbank, who has been mentioned before, is a flower lover as well as a skillful breeder of useful plants. One day he was looking at a field of California poppies, yellow in the sunlight. His quick eye detected one blossom that had 'a thread of crimson on the inside of one of the petals.' He saved and planted the seed of the crimson-streaked poppy. It produced

yellow poppies some of which were marked with red. Seed was saved from those showing most red. In nine years, by this continued careful selection, a brilliant crimson poppy was produced, like its yellow ancestor in all respects except color.



Courtesy of New Mexico Agricultural Station

GAILLARDIAS

these should not be planted until the ground is warm.

Some annuals, such as the pansy, thrive in shady places, but most of them prefer full sunlight. They need deep, fertile, mellow soil.

Seed Beds.—Most annuals thrive better if raised in seed beds and transplanted. A good seed bed is a shallow box with its bottom open enough to secure good drainage. It should be filled with fine, rich, well-packed sandy loam, kept moist and warm. Most flower seeds are small, and care must be taken not to cover them deep; if this be done, they will not germinate.



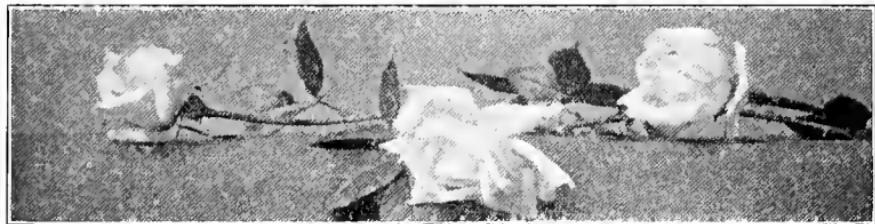
CARNATION
PINKS

Nor must the seed bed be watered so freely as to form a crust or rot the seeds.

Flowering Plants. — Many of our flowering plants are biennials and perennials. Among these are the peony, hollyhock, ver bē'na, chrys ān'the mum, clēm'a tis, honeysuckle, and rose. Some of these are raised from seeds, but most are grown from cuttings of roots or stems or from division of roots.

Among the most popular perennials are some tubers and bulbs. Like agricultural root crops, flowering ones need deep, fertile, well-drained soil. Among the spring blossoming bulbous plants are the odorous hē'y'a cīnθ, the brilliant tū'lip, the fragrant and bright-colored nar cī's'sus, dāf' fo dil, and jōn'quil, the graceful snowdrop, and the sweet-scented lily of the valley. Later in the season bloom the beautiful lilies and the showy gla dī'o li and dāh'lias.

Roses. — Of all flowers, perhaps the general favorite is the rose, to which has been applied the title of 'queen of flowers.' It

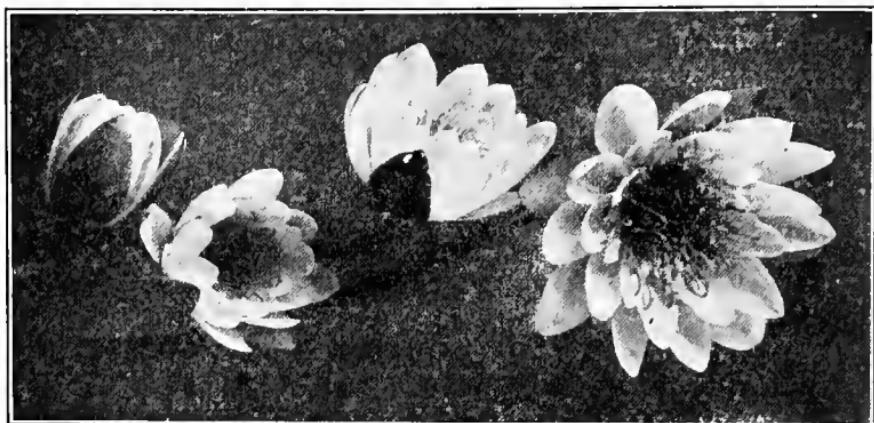


ROSES

has for its own the entire blooming season of the year. It has all charms, — fragrance, grace, beauty, and variety of color. Roses need sunshine and a deep, fertile, well-drained soil. Hardy varieties will endure a good deal of neglect, but no flower better repays intelligent care.

Success in raising Flowers. — If you wish to succeed in raising flowers, you must study the nature and the needs of the varieties

you wish to grow. Their preferences as to soil, moisture, and sunlight must be regarded. They must have careful cultivation, the soil being kept stirred on the surface, but not so deep as to interfere with their roots.



A GROUP OF WATER LILIES

Many flowers, such as sweet peas, have their blossoming season prolonged by keeping the blossoms picked so as to prevent the maturing of seed.

A few plants well cared for give far better results than a large number poorly tended or neglected.

EXERCISE

1. Set aside a part of your garden plot for flowers. Plant some hardy annuals, such as phlox and nasturtium.
2. Compare an American Beauty or other cultivated rose with the wild rose, or sweetbrier.

OUTLINE OF CHAPTER FIVE

CROP ENEMIES AND FRIENDS

Weeds:

Some annuals:

Charlock, chess, corncockle, dog fennel, pigeon grass, cocklebur,
horse weed, wild lettuce, ragweed, Russian thistle

Some biennials:

Bull thistle, burdock, wild carrot

Some perennials:

Bind weed, Canada thistle, dandelion, horse nettle, nut grass,
oxeye daisy, rib grass, sorrel, wild onion

Destroyed by

Clean, cultivated crops

Preventing the maturing of seed

Smother crops

Fungous Diseases:

Some characteristics of fungi:

Feed on other plants and animals

Lack chlorophyl or leaf green

Reproduce by spores instead of seeds

Some fungous diseases:

Blight, black knot, mildew, mold, rot, rust, scab, smut, wilt

How to protect crops:

Destroy fungi, —

On soil, by burning diseased plants

In soil, by depriving them of host plants

Plant and breed resistant varieties

Store fruit and grain when they are dry

Remove spores from infested seed

Destroy spores of fungi by

Dust spray of flowers of sulphur

Liquid spray of copper sulphate, lime, and water (Bordeaux
mixture)

Insect Enemies:

Characteristics of an insect:

Breathes through tubes on body

Has six legs

Body is in three parts,— head, thorax, and abdomen

Several life stages,— egg, larva, pupa, imago, or egg, nymph, adult

Some chewing insects that feed on plants:

Canker worm, army worm, tent caterpillar, cabbage and tobacco

worms, cotton boll worm, cutworm, Colorado potato beetle

Some chewing insects that feed in plants:

Curculio, borers, Mexican cotton boll weevil

Some sucking insects:

Aphides or plant lice, Hessian fly, chinch bug, scale

Means of controlling:

Cultural methods,—

Tillage, fertilizers, trap crops, time of planting, rotation of crops

Poison,—

Arsenic for chewing insects

Contact poisons, such as lime, for sucking insects

Insect Friends:

Ladybirds, ground and tiger beetles, dragon and damsel flies, ichneumon and tachina flies

Birds:

Some useful ones:

Swallows, cuckoos, woodpeckers, sparrows, wrens, kingbird, mocking bird, partridge, Baltimore oriole, bluebird

Some useful ones that do some harm:

Robin, catbird, bobolink or rice bird, red-winged blackbird, crow

Some harmful ones:

Sharp-shinned hawk, Cooper's hawk, goshawk, duck hawk, English sparrow

How to have bird neighbors:

Do not disturb their nests

Put nest boxes and water in convenient places

Feed birds when snow is on the ground

Plant mulberries and seed-bearing shrubs

CHAPTER FIVE

CROP ENEMIES AND FRIENDS

WEEDS

What Weeds Are. — Weeds are well defined as ‘plants out of place,’ those that persist in growing where they are not wanted. Usually, they are wild plants. Sometimes they are cultivated ones which cannot be kept in bounds. The beautiful Kentucky blue grass is a weed when it grows in a hayfield; it is not tall enough for hay, and it crowds out other grasses that are.

Weeds are not altogether useless or harmful; they shade the land, they supply humus, and they remind farmers that it is time to till their crops. Some farmers do not consider the benefits of tillage, and think it is necessary to cultivate a crop only often enough to keep weeds in check.

Agricultural Plants. — Our agricultural plants have been selected from among wild plants for some useful quality, and brought into field, orchard, or garden. They have been cared for so long that they have, to a great extent, lost ability to care for themselves. Most of their vigor is spent in storing up the products for which they are cultivated. They are cotton-bearers, grain-growers, fruit-producers.

Harm done by Weeds. — Weeds, on the other hand, are used to shifting for themselves, and are generally stronger and quicker-growing than agricultural plants. They rob crops of food, moisture, and light. They lessen the quantity, and often injure the

quality of the yield. Wheat is damaged by cockle, wool is injured by burs, the flavor of milk and butter is affected by wild onions.

Water hemlock and some other plants are poisonous to man and beast.

How to destroy Weeds. — The good farmer tries to destroy weeds while young, before they injure the crop. They are then easily killed by shallow hoeing with a hand or horse hoe or a cultivator with small teeth. If weeds are cut off too near the surface, their roots live and send forth new growth; if they are cut off too deep down, they are only transplanted and grow more vigorously.

Weed Seed Sowing. — But how do weeds come in the fields where they are not planted?

Ah! that is a matter to which they attend. The farmer is fortunate if he gets his field crops sowed as thoroughly as those weeds. In the first place, they usually produce an enormous number of seeds. A single plant will sometimes mature a hundred thousand seeds one season.

To spread these abroad, weeds make use of many messengers,—wind, water, birds, beasts,—yes, and people, too. Every time you pull off one of the hooked burs which



COCKLEBUR



BROOM SEDGE

Seed carried by wind

has caught fast in your clothing, and throw it down on the ground, you are carrying out the cocklebur's plan of seed sowing. If you do not wish to reap burs, do not sow them; burn them instead.

Weed Travelers. — Weeds are such great travelers that they are called the 'tramps of the vegetable world.' They do not travel only in slow, old-fashioned ways, helped by wind and wave and animal. They travel with all the conveniences of the age, — by rail and boat. Their seeds are often carried from one country to another in hides, in fleeces, in hay, and mixed in other seed, such as grass or grain.

Native and Foreign Weeds. — Few of our native weeds are troublesome in the crop field. They have been used to contending only with other native plants, and have not, as it seems, adapted themselves to the struggle with man and his agricultural tools. They retire to the forest and untilled land.

Our most troublesome weeds have been imported from Europe. For centuries they have been struggling for existence there, and they are bold, hardy, and persistent.

Weedless China. — There is one country almost entirely free from weeds. That is China. It is an old country, so thickly peopled and so occupied with crops that weeds are crowded out. This is the only way they are ever destroyed, — by careful tillage and by occupying all the land with crops.

How to keep Weeds in Check. — As it will probably be several thousand years before our country is as densely populated as China, American farmers must work to keep weeds in check. They can do so by good tillage, rotation of crops, occupying the land with crops, protecting the insect and bird enemies of weeds, and destroying troublesome weeds.

A farmer who does not fight weeds both out and in his crops is

apt to have an infested farm. He lets the daisies go to seed in his pasture and they take possession of it. He leaves the thistle in the fence corner, the cocklebur and burdock by the brook, and they sow thousands of seeds. Perhaps he does not practice rotation of crops; certain weeds take advantage of the habits of certain agricultural plants, and become established with them. He leaves land out to 'rest,' and a weed crop grows on the grain stubble. A 'resting' field is a weed nursery which raises hosts to occupy that and other fields next year. When the farmer plows under their ripened seeds, he plants a crop as surely as when he plows under wheat or oats. The production of a crop of weeds is as great a tax on soil fertility as an agricultural crop, such as cowpeas, which benefits the farm and the farmer.

Knowledge Needed. — The farmer must understand the nature and habits of his crop plants in order to grow them successfully. He must understand those of weeds if he is to carry on successful war against them.

Annuals. — There are many troublesome annuals. As a rule, they are not so persistent of growth nor so deep of root as longer-lived plants, and thus are easier to destroy. They usually produce seed very freely. Among annual weeds are charlock, chess, corn cockle, dog fennel, pigeon grass, bur grass, cocklebur, horse weed, wild lettuce, ragweed, and Russian thistle.

Ragweed. — The ragweed is one of our few troublesome native annuals. It has many local names, — bitterweed, hogweed, little ragweed, richweed, Roman wormwood; its botanical name is *Am brō'si a ar te mī'si ae fō li a*. As plants have so many local names, it is a good plan to learn the botanical name, which is the same everywhere. Ragweed is found in almost all states east of the Rocky Mountains. It branches freely and its leaves are much divided. The greenish stamen-bearing and pistil-bearing flowers

are borne in different places on the same plant. It infests cultivated fields, and often grows as thick in grain stubble as if it had been sowed there.

Ragweed can be destroyed by late cultivation in hoed crops, and by plowing grain land and sowing on it such crops as cowpeas or clover. Stray ragweed plants along fences and streams should be cut down before they scatter abroad their hosts of seeds.

How to destroy Annuals.—Most annuals are easily destroyed by clean cultivation of crops, especially by late cultivation. As far as possible, seeding should be prevented. The plants should be mowed before they flower, or burned before the seed mature.

Biennials.—Among our most troublesome biennial weeds are the bull or pasture thistle, burdock or



FOUR COMMON WEEDS

a, amaranth; *b*, crab grass; *c*, ragweed; *d*, pigeon grass

great dock, and wild carrot. None

of these are native Americans; all have been brought from the Old World.

Wild Carrot. — The wild carrot (*Dau'cus ca rō'ta*), called also bird's nest, devil's plague, or Queen Anne's lace, is a troublesome

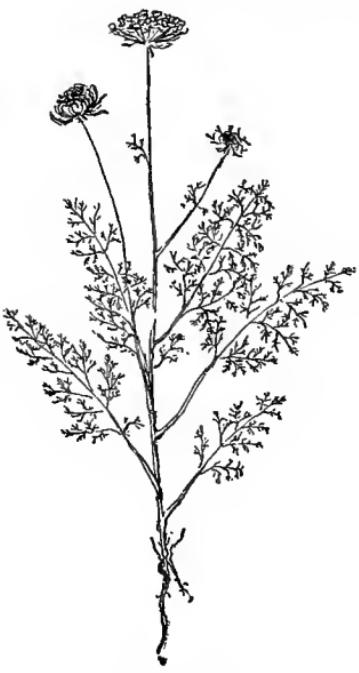
biennial, the original of our garden carrot. It grows from New England southward to Georgia and westward to Ohio. It is so troublesome in some states that laws have been passed against letting it go to seed. The wild carrot has a pretty white blossom and graceful, finely-cut foliage. It thrives on almost any soil and takes possession of waste places. The best way to destroy it is to pull the young plants up by the roots, or to cut them before they mature seed.

How to destroy Biennials. — Biennials are more difficult to get rid of than annuals. When young, they can be destroyed by cutting or pulling them up. When they are several months old, they can be removed only

by deep cutting with a grubbing hoe, or with a spud, which is a sharp, narrow spade. Any plant which escapes the hoe should be cut before it blooms. Weeds, especially biennials and perennials, should never be allowed to mature seed.

Perennials. — The most troublesome of all weeds are the perennials. Most of these long-lived plants are reproduced both by seeds and by running roots, and their destruction is difficult.

Among perennial weeds are the bindweed or morning-glory,



WILD CARROT

Canada thistle, dandelion, horse nettle or sand brier, nut grass, oxeye or white daisy, rib grass or English plantain, sorrel or sour weed, and wild onion or field garlic. Nearly all of these have been imported in grass or grain seed from Europe. Many of our native poisonous plants are perennials.

Daisy.—The white-and-yellow daisy (*Chrysanthemum leucanthemum*) is a cousin of our much-prized chrysanthemum. It has a pretty flower, but is one of our most troublesome perennial weeds. Throughout the eastern part of the United States, from Maine to North Carolina, farmers regard it as an enemy.

It is not difficult to destroy in cultivated crops, but it spreads so rapidly in meadows and pastures that it soon crowds out the grasses. It can be killed by hoed crops, or checked in hay fields by mowing early before it matures seed.

Loco Weed.—The woolly loco weed and the stemless loco weed are peculiar poisonous perennials of the Great Plains region. They are found both on the prairies and on the foothills and mountain sides. They are called 'crazy weeds' because their effect on stock is like that of alcohol or morphine on human beings. Cattle, sheep, and horses that eat these weeds are said to be 'locoed'; they are affected with mania, refuse all other food, and finally die. Loco causes an immense loss every year to the livestock owners of the West.





STEMLESS LOCO WEED

One third natural size

How to destroy Perennials. — Perennial weeds have to be fought in different ways. Some yield to clean cultivation of crops. Others are so persistent in clean crops that they are more easily destroyed by a 'smother' crop, — a sowed crop which makes rapid, dense growth, and deprives the weeds of light and air. Cowpeas and other quick-growing legumes are excellent for this purpose.

EXERCISE

1. We have mentioned here only a few of the many weeds troublesome to farmers in the United States. Make as complete a collection as you can of the weeds of your locality. Get the whole plant, — root, stem, branches, and blossoms. Collect weed seeds also.

2. Write an account of the most troublesome weeds with which you are familiar. Are they annuals, biennials, or perennials? How do their seeds travel? In what other ways are they reproduced? In what crops are they especially troublesome? What are the best and most economical ways of getting rid of them?

FUNGOUS DISEASES

Advantages of Commerce. — The railroad and the steamship have bound together all parts of the world. People are fed on fruit, vegetables, grain, and meat produced in other states, other countries, other continents. This interchange of produce is in many ways a great advantage. It enlarges markets, it lessens

suffering from crop shortages and failures. If the wheat crop of the United States be small, the surplus of Russia furnishes us bread. If America has a bountiful crop, it goes to supply food for Europe.

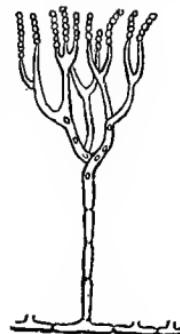
Disadvantages. — But this intercourse has its disadvantages. As you learned, many troublesome Old World weeds have been brought to us in one way and another. Other and more deadly crop enemies have been imported. Diseases and insects, once confined to localities, have spread over the world.

Fungous Diseases. — Old farmers remember when fungous diseases of crops were almost or entirely unknown. Fruit ripened, vegetables grew, grain matured, without any serious injury. Now there is hardly a farmer who does not lose by these diseases every year. Usually, he loses heavily unless he uses preventive measures.

Fungi. — A fungous disease is one caused by fungi, — plants which live on other plants or animals and take nourishment from them. One such plant is called a *fün'güs*. Some fungi, such as mushrooms, are large; others, such as blight, are very small, so small that they are invisible to the naked eye. Some, such as the yeasts, are useful; others, such as the smuts, are harmful. Some cause deadly diseases; without others, man would die, because it would be impossible to raise any food crop.

Three well-known classes of fungi are mold, yeast, and bacteria.

Fungi are the lowest forms of living things. They lack the chlorophyl by means of which, as you have learned, higher plants feed on the elements of the air. Instead of being green, they are usually white, pink, yellow, blue,



MOLD

Greatly magnified

or brown. Instead of seeds, they produce spores, minute bodies which bud or break off from the fungi. These reproduce with wonderful rapidity. One plant may produce several millions within twenty-four hours. Spores are so small and light that they are borne far and wide in the air.

Some fungi perish under unfavorable conditions. Others establish a colony on a host, as the plant or animal on which they fasten themselves is called. A very unwilling host it is, we may be sure, which is deprived by its guest of tissue or juices or even of life. The fungi penetrate the cell walls of their host, devour the protoplasm which, as you have learned, is the living principle; they destroy cell after cell, and weaken or kill the host plant.

Bacteria are so small that they have to be magnified before we can perceive them at all. Under the microscope, they are seen to have one of three forms; they are 'shaped like balls, pencils, or corkscrews.'

You have learned that some bacteria help the farmer by changing nitrogen into forms which plants can use, and others harm him by consuming soil nitrogen. There are other fungi which harm him by feeding on his crop plants, producing such diseases as rot, rust, smut, mildew, blight, scab, and wilt.

It is important for the farmer to learn something about fungi. He is then better able to get the aid of the helpful ones and to check the ravages of the harmful ones.

Fire Blight. — The bacteria which cause fire blight of fruit trees are carried by insects at blossoming time. Thus they spread from tree to tree, from neighborhood to neighborhood. The bacteria use the food prepared in the leaves for the tree, and kill leaves, twigs, branches, often the tree itself. The disease is called fire blight because the leaves affected look as if they had been scorched by fire.

When these withered, blackened leaves are seen, the twig bearing them should be cut off some distance below the darkened place which shows how far the disease extends. These twigs should be burned in order to destroy the bacteria. The knife should be disinfected after each cutting, so as to keep from infecting healthy wood.



Courtesy of Connecticut Agricultural Station

MUSKMELON VINE WITH BLIGHT

Rust. — There are many forms of rust which affect different plants. The rust of the apple is an interesting example of a fungus which has two hosts, one affording it a summer home, the other giving it winter quarters.

The winter home of the fungus is the red cedar, on which it forms what is called the cedar apple. In wet spring weather these cedar apples are covered with jelly-like tissue, which is a

mass of spores that are cast off in enormous numbers. They float through the air to find a home on the apple foliage. They penetrate the tissue, forming orange-colored spots which injure and

often destroy the foliage. On the under side of the spots are small cup-shaped bodies which bear the spores. Later, these spores float back and infest the leaves of the cedar. The fungus cannot live if deprived of either of its host plants. It is most easily kept in check in an apple orchard that has no cedar trees near it.

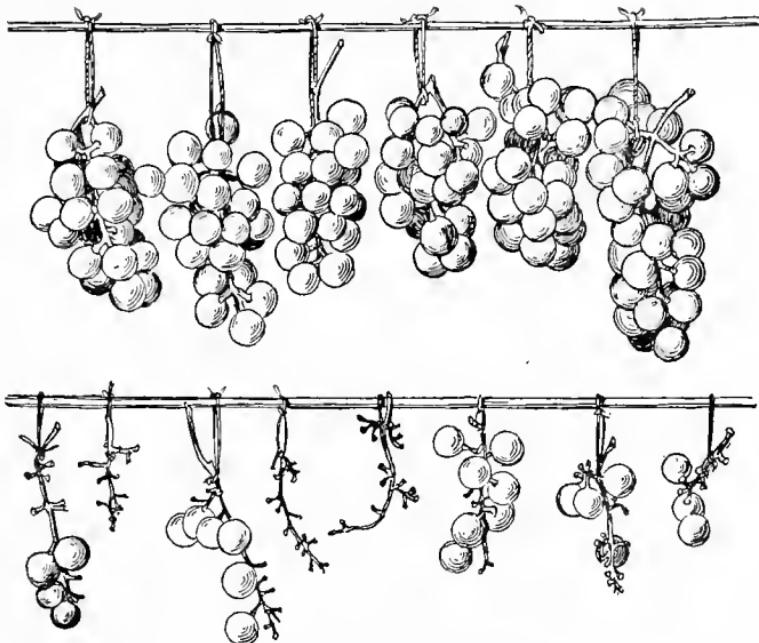


Apples infected with bitter rot from "mummy" of last year's fruit

Rot.—Most kinds of fruit rot are very contagious, and sound fruit is rapidly infected by diseased. One day there may be only two or three decaying peaches on a tree; a week later it may be impossible to find a sound one.

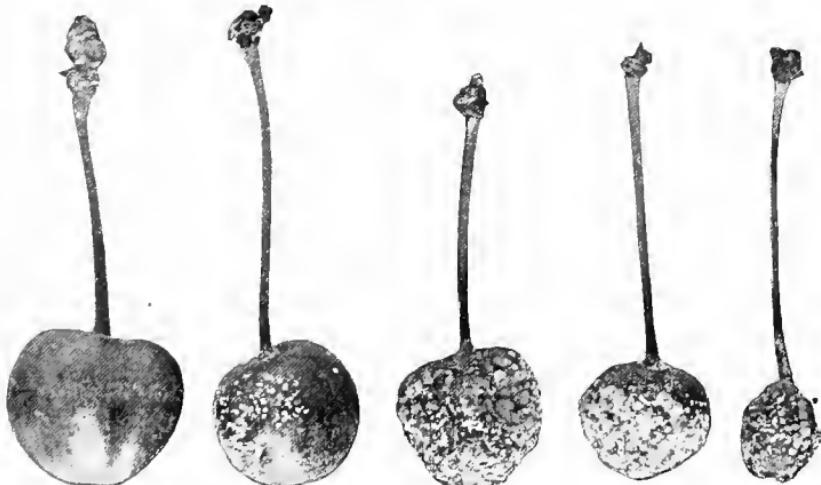
As an experiment, a knife blade was inserted first in a speck of bitter rot on an apple and then in a sound apple, which was put in a basket of healthy fruit. The apples were attacked by bitter rot, and in a few days every one in the basket was destroyed.

Smut.—There are different kinds of smut that infest cereals. The smut grows with and on the plants. Its spores, thousands and thousands together, resemble a black powder in the heads of



GRAPES FROM A VINEYARD AFFECTED WITH BLACK ROT

The upper bunches were on a vine that was sprayed with Bordeaux mixture; the lower ones were on an unsprayed vine.



CHERRY WITH BROWN ROT, SHOWING THE PROGRESS OF THE DISEASE

grain, such as wheat or oats. When the grain is threshed, these spores adhere to the grains and are planted with them. They develop and attack the young plants. The farmer does not wish to raise a crop of smut to feed upon his grain and lessen its yield. Therefore he should kill the smut spores on infected grain by the use of *fôr'ma lin*, as described on page 307 in the appendix.

Wilt. — Wilt is a disease which attacks cotton, flax, tobacco, cowpeas, and other crops. It is caused by bacteria in the soil,



Courtesy of North Carolina Experiment Station

TOBACCO, SHOWING DIFFERENT STAGES OF WILT

which enter the plant, probably through the root hairs, and spread up into the stem. There they grow, and choke the passages so that the flow of sap from root to foliage is lessened or stopped. As their supply of water is evaporated, the leaves wilt and wither. Later, the stem blackens and rots. Sometimes only a few plants in a field are affected, sometimes all are attacked. Care must be taken not to spread the disease by carrying infested plants off the field where they grew. They should, if possible, be collected and burned there.

As the fungi persists in the soil often as long as eight years, the same crop should not be planted on that field for several years. Instead, there should be planted crops, such as corn, that are not subject to wilt diseases. Wilt-resistant varieties of cowpeas, cotton, flax, and other plants have been bred by selection, but rotation of crops should never be neglected, even when these varieties are used.

Preventives for Fungous Diseases. — The damage of fungous diseases in fields, orchards, and gardens amounts every year to millions of dollars. Is there no way to prevent this loss? Yes, there are remedies for most of these diseases, remedies both cheap and effective. The farmer should know and use them. He should bear in mind the fact that most fungous diseases are contagious, and that they spread by means of spores which increase very rapidly. He should know and guard against the various host-plants of a fungus, and should know at what season it attacks its hosts.

How to destroy Fungi. — A farmer ought to destroy the fungi in and on the soil as far as possible. He can do this in two ways.

First: He should burn diseased plants. Diseased vegetable matter, such as twigs affected with blight, tobacco and cotton which die from wilt, apples shriveled with bitter rot, should be collected and burned. Usually this should be done on the field where they are gathered, so as not to spread disease.

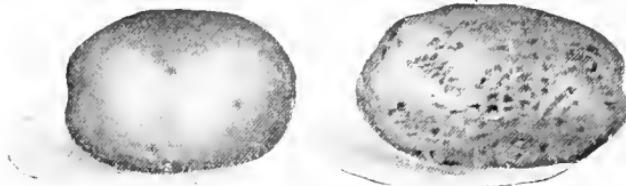
Second: The fungi in the soil should be destroyed by starving them. Host plants should not be grown for several years on a field where they have been attacked by soil fungi, — tobacco with wilt, sweet potatoes with rot.

The farmer should protect his crops against common diseases by planting and by breeding resistant varieties. There are rust-proof varieties of oats, and wilt-proof varieties of many plants subject to this disease. Our native gooseberries resist mildew better

than the English ones. Oriental pears are not so subject to blight as European varieties.

Fruit and grain should be stored dry and in good condition. Fungi require food in a moist state, and are apt to attack fruit and grain when they are put away damp.

Spores should be removed from seeds to which they adhere. Grain affected with smut, and po-



HEALTHY POTATO

POTATO WITH SCAB

tatoes with scab, should be treated with formalin just before planting. The preparation is inexpensive and easily applied.

Usually, fungi feed in and on the tissue, and are protected by the thickened outer skin of the host plant. The fungi already established in a plant cannot be killed except by treatment which would destroy the host also. Therefore, treatment for fungous diseases must be largely preventive, destroying the spores before they enter the plant cells.

Fungicides. — Fungi, unlike higher plants, are made up of absorptive tissue. This tissue will absorb flowers of sulphur or salts of copper, either of which is destructive to it. Sulphur is usually applied as a dust-spray to the plants to be protected. Copper sulphate, or bluestone, is the cheapest and most effective form of the salts of copper. The copper sulphate, dissolved and diluted in water, is used on bark, limbs, and unopened buds. But it should not be used on foliage which its acid will burn and injure.

Without affecting its value as a fungicide, or fungus-destroyer, the copper sulphate may have its acid neutralized by an alkali, such as lime. Two thirds of a pound of unslaked lime will neutralize the acid in one pound of copper sulphate. A mixture

of lime and copper sulphate in water, called Bordeaux' (dō) mixture, is generally used for fungous diseases affecting foliage and fruit. It should be applied thoroughly as a fine mist. The for-



Courtesy of New York Agricultural Station

SPRAYED AND UNSPRAYED POTATO VINES IN A FIELD AFFECTION WITH BLIGHT

mula for Bordeaux mixture and directions for its preparation are given in the appendix on page 307.

EXERCISE

1. Keep a piece of bread several days in a damp, warm place. Examine under a microscope the mold which forms on it.
2. Cut a sound apple with a clean knife and seal it in a clean, dry jar. Cut another sound apple with a knife that has been inserted in a rotten one; then seal the sound and rotten apples in a jar together. What are the results?

3. Take two potatoes affected with scab. Wash one in the formalin preparation described in the appendix on page 307. Plant both. What is the difference in the appearance of the crop from each?
4. Examine plants affected with fungous diseases. What are the most troublesome fungous diseases of your locality? What crops do they attack, and what remedies are used?

INSECT ENEMIES

Injuries from Insects. — Of all the creatures of the animal world, which inflict most injury on man? You think first of the beasts of the field, — fierce lions and man-eating tigers. But man has worse foes than these. You name the serpents, — venomous rattlesnakes and deadly cobras. Yet it is not they that inflict most injury on the human race.

More harm and ruin and death have been caused by insects than by all other creatures of the animal world. Indeed, we are only beginning to realize the extent of their injuries, — as, for instance, that they convey germs of diseases, such as malaria and yellow fever.

But though their work as messengers of disease is just being made known, their work as messengers of want and famine is an old story. Since Pharaoh ruled in Egypt, thousands of years ago, history has been recording plagues of insects. They come on foot in hosts such as no human army ever gathered; they come on wings so that the face of the earth is darkened. They find fair fields and bountiful crops and leave behind — not one green twig nor blade of grass.

By skill and labor man has learned to some extent to control them and to prevent their ravages. Yet every year in the United States insects destroy at least one tenth of the agricultural crops.

They cause the farmers of the country an annual loss of not less than five hundred million dollars.

At least two thirds of this loss might be prevented by proper methods and remedies. Is it not the part of wisdom for every farmer to know and practice these? In order to use them, he must know the insects most apt to injure his crops, their different forms in different stages, their habits of feeding, and when and how they can be most easily and economically destroyed.

An Insect.—An insect is a small animal which breathes air through its body, has six legs, and a body divided into three parts—head, *thō'rax*, and *ab dō'men*. On the head are the mouth, the *an tēn'næ* or feelers, and the eyes. The thorax is in three parts, on each of which is a pair of legs. Some insects are wingless, but most adult insects have one or two pairs of wings on the thorax. On the abdomen are tubes, called *spir'a cles*, through which the insect breathes.

Ants, flies, bugs, beetles, grasshoppers, moths, and butterflies are insects. Spiders, which are often called insects, have eight legs, and belong to a different class of animals of the same group.

Insects usually pass through four stages,—egg, *lär'va*, *pū'pa*, *i mā'go*.

Larva.—The insect comes from the tiny egg as a larva, a worm-like creature very unlike the parent. The larvae are greedy feeders. They eat, literally and truly, all that their skin will hold. When the skin cannot stretch any more

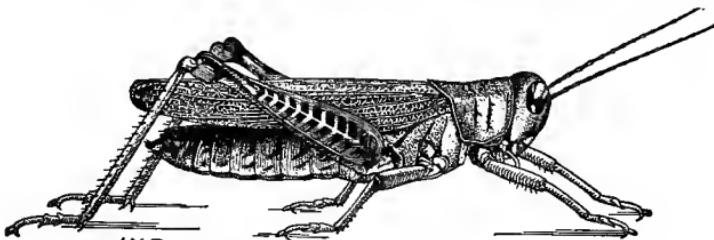


CANKER WORMS ON APPLE LEAVES

they molt, or cast, that skin and grow a new one. They repeat this process several times until they are full-grown.

Pupa. — The insect next enters the pupa state. The larva ceases to eat; it does not move. You would think it dead. But it is only asleep, and in its sleep a wonderful change takes place. The creeping, crawling worm changes to an imago, a winged creature.

Imago. — It waves its wings to and fro, and flutters from flower to flower. Who would ever guess that it was once a dull worm, that fed on the leaves of plants? Instead of feeding greedily on



A FULL-GROWN GRASSHOPPER

leaves, it sips nectar from flowers. It lays its eggs in a protected place where its young can find suitable food. Soon after it lays its eggs, it dies. This is the life history of a perfect winged insect, such as the butterfly. Moths resemble butterflies in appearance, but fly abroad chiefly at night, or in the dusk, instead of by day, as do butterflies.

Nymphs. — Every insect does not pass through all these stages. Some, such as bugs and locusts, or grasshoppers, have only three stages, — egg, nymph, and a dult'. The nymphs resemble the adults, and attain their growth by molting, without entering the pupa state.

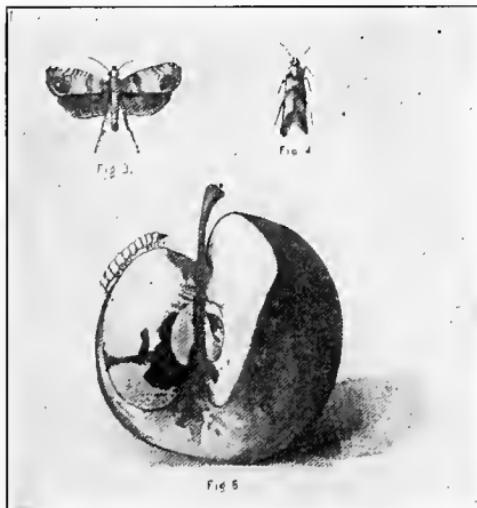
Larvæ. — It is as larvæ that insects are usually most injurious to crops, but it is often easier to kill them in other stages. If we

know that a destructive worm will issue from the harmless-looking pupa, we will crush it. If we realize that the moth flitting about our yard will lay hundreds and thousands of eggs that bring forth injurious caterpillars, we will give her swift and painless death.

Moths.—The worms and caterpillars most destructive to crops are the larvæ of moths. Among these are the canker worm, the army worm, the tent caterpillar, the cabbage, tobacco, and currant worms, the cotton boll worm, the cutworm, and the larvæ of the codling moth and gypsy moth.

Codling Moth.—The codling moth is one of our imported pests. It lays its eggs on young apples just after the blossoms fall. An egg hatches into a larva which burrows into the fruit and feeds on it. This causes the apple to fall before it is ripe. The full-grown larva leaves the apple and crawls up the tree trunk, enters the pupa state, and issues as a moth.

The easiest way to deal with this pest is to trap the moths by bands of cloth wrapped around the tree trunk. The moths collect under these and can be destroyed. The tree should be sprayed or dusted with poison as soon as the blossoms fall. It is useless to spray against the larvæ after the blossom-end turns downward, as they are then protected by the position of the fruit.



An apple injured by the larva of the codling moth, which is shown on the apple; above, is shown the moth.

If unchecked, they often destroy from one fourth to three fourths of the apple crop. It costs millions of dollars every year to spray fruit trees in order to protect them against this pest. There is a fly, described later, which helps the farmer by destroying the larvæ of the codling moth.

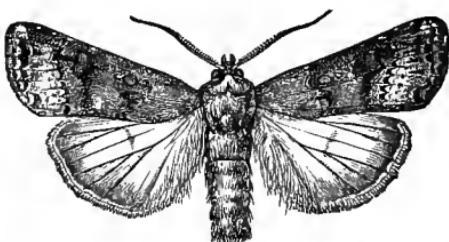


A TOBACCO CUT-WORM

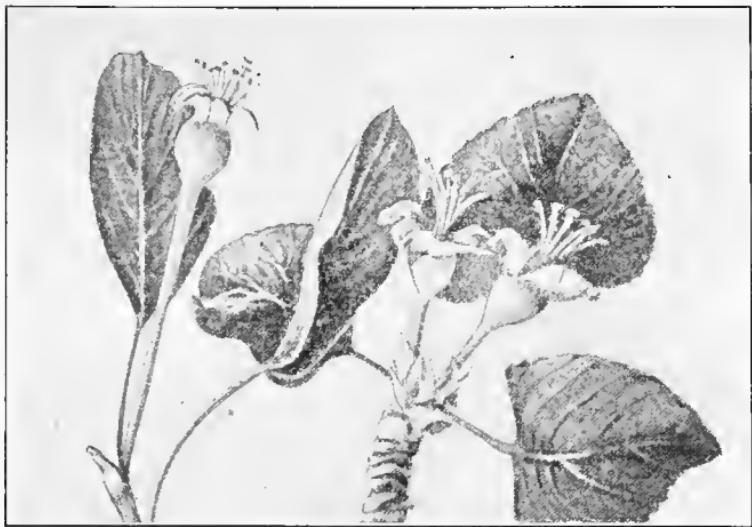
Cutworms.—Cutworms are the enemies of almost all garden plants and of many field crops. The name is applied to the larvæ of different moths, which are so similar in appearance and habits that they may be described together.

The adult moths have dark fore wings and lighter hind wings. They lay their eggs about midsummer. The larvæ soon hatch and begin to feed, but on the abundant summer foliage their ravage is hardly noticed. In the fall they hollow out cells in the earth, where they sleep through the winter. In the spring they come out and feed greedily on the tender young plants. They cut these off at the surface and eat the stem and leaves. Like the parent moths, they usually feed only at night; but when food is scarce they feed in the day. When full-grown, cutworms are dull brown, gray, or greenish in color. They enter the earth and remain there in the pupa state till summer, and then come out as moths.

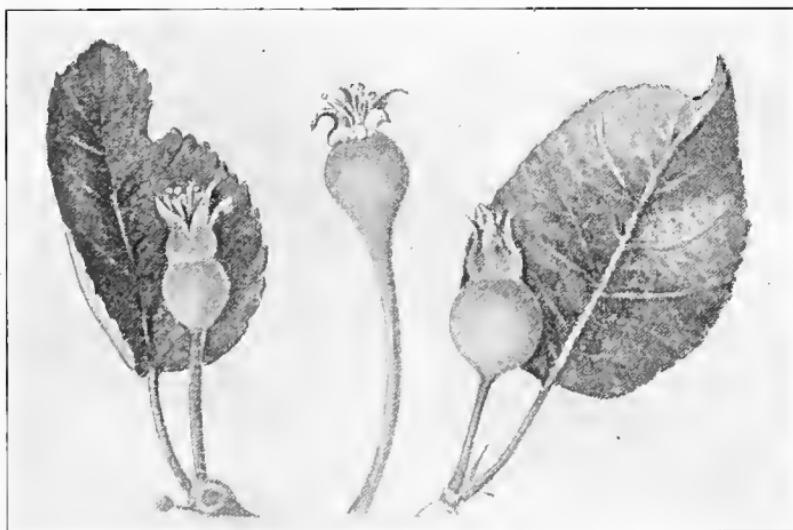
The best way to destroy cutworms is by thorough cultivation and by poison. Weeds and grass in fields about to be cultivated may be sprayed with Paris green, or the poison can be applied to bunches of clover or grass scattered where cutworms are troublesome.



THE MOTH OF THE TOBACCO CUTWORM



THIS TWIG, FROM WHICH THE PETALS HAVE JUST FALLEN, IS READY FOR SPRAYING AGAINST THE CODLING MOTH.



Courtesy of New York Agricultural Station

IN THIS TWIG THE BLOSSOM ENDS ARE CLOSING, AND IT IS ALMOST TOO LATE TO SPRAY AGAINST THE CODLING MOTH.

Beetles. — Beetles have four wings. The fore wings, called sheath wings, are hard and often bright-colored; the thin hind ones are kept folded under the sheath wings. Beetles are often injurious in the imago as well as in the larva form.

Colorado Potato Beetle. — This is the case with the Colorado potato beetle. It was an invasion of this insect that brought about

the use of Paris green as an insecticide, which has saved millions of dollars' worth of crops. The potato beetle is a native of the Rocky Mountains. There, it feeds on weeds of the nightshade family, to which the potato belongs. Within thirty years, it has extended its home to most parts of the United States.

The black-and-yellow beetle winters in the ground. It comes out in the spring and feeds ravenously on the potato, horse nettle, and eggplant. The female deposits its little yellow eggs—

six hundred to a thousand in number — in patches on the under side of the leaves. These eggs hatch in a few days into slug-like larvae. The beetles are hungry, but the larvae are ravenous. They feed greedily for four or five weeks, then enter the ground and come forth in a few days as beetles. There are three or four broods every season.

To stop the ravages of beetles, hand picking is used to some extent, but poison is the best remedy. The farmer is aided in the work by some birds, especially crows, by ladybird beetles, and by

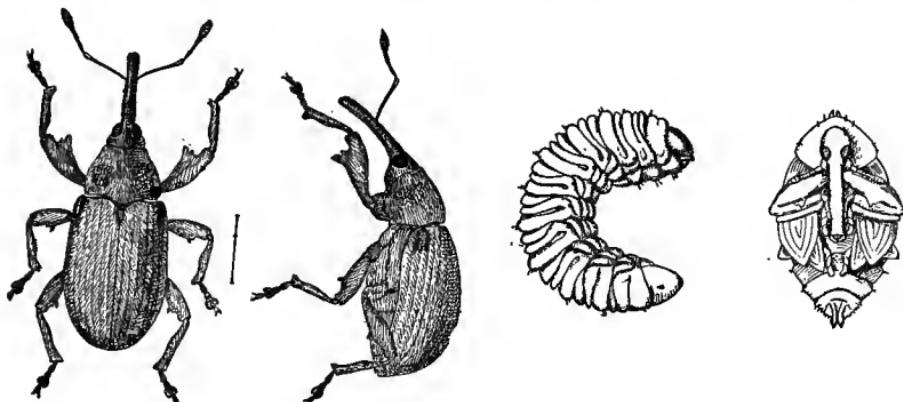


COLORADO POTATO BEETLE

Beetle, larva, and eggs are shown on this spray of a potato plant.

several kinds of bugs and ground beetles which feed on the potato beetles and their larvæ.

Mexican Cotton Boll Weevil.—The Mexican cotton boll weevil is so destructive that it has caused the cultivation of cotton to be abandoned in large areas in Mexico. About fifteen years ago the weevil was brought into Texas, and in the region invaded it has caused a loss of from twenty-five to ninety per cent of the cotton



MEXICAN COTTON BOLL WEEVIL, BEETLE, LARVA, AND PUPA

Five times natural size

crop. It is now found in one third of the cotton section, and is extending its range year by year. Our American farmers are not disposed to surrender their cotton fields to the boll weevil, as did the Mexicans. Labor and science have found ways of lessening its injuries, and probably a method will be discovered, sooner or later, of controlling it.

The insect which does so much mischief is a small grayish beetle about one fourth of an inch in length. With its snout it makes a hole in the cotton square or boll, and there deposits an egg. This becomes a grub, which lives in and feeds upon the square or boll.

It causes a square to drop; usually, a boll remains on the plant, but it becomes stunted and dwarfed and the fiber is ruined.

The larva, when full-grown, is about three eighths of an inch in length. It then enters the pupa state and becomes a beetle. This round of life takes about four weeks. As the bolls dry in the fall,

the beetles leave them and seek shelter under rubbish, trash, or weeds, where they spend the winter.



Cotton bloom hollowed out by boll weevil larva

Since the weevil life is spent and its damage done chiefly in the square or boll, poison and picking cannot be used to any extent. Colonies of ants are being introduced into Texas, which feed on the weevil and may help keep the pest in check. Attempts which may be successful are being made to breed a weevil-resisting variety of cotton.

The best way yet devised to control the weevil is by cultural methods. Trash in and around fields which affords winter quarters for the beetles should be burned. They are most destructive late in the season, and do not seriously injure an early-maturing crop. This may be secured by the use of early varieties and northern-grown seed and of fertilizers, and by thorough and frequent cultivation of the crop.

Chinch Bug.—The chinch bug injures small grain and corn, and has done more damage than any other insect in the grain-grow-

ing sections of the United States. The loss caused by it amounts to hundreds of millions of dollars.

It is a harmless-looking little bug, about one fifth of an inch long, with a black body and white wings. It winters under clumps of grass and rubbish or in cornstalks. In spring it comes forth and the female lays about one hundred and fifty eggs, which hatch in two or three weeks into reddish little bugs. These feed on the grain plants, and are full-grown just about harvest time. When wheat is cut, they go to oats, and after oat harvest they go to the cornfields.

The period of their migration is the only time that man can attack them with any degree of success. Though they have wings, they travel on foot. If a ditch or deep furrow with steep sides of pulverized earth be put around the fields, they fall in, and can be crushed or killed with kerosene spray. A strip of coal tar an inch or two wide will also catch and destroy them.

San José Scale. — One of the most destructive insects in orchards is the San José (ho sā') scale. It is so small that it is invisible to the naked eye, the mature insect being only one thirty-second of an inch in length. Yet, if unchecked, they kill shade and fruit trees, often destroying whole orchards. They were introduced into California about 1870, and thence have spread to nearly every state in the Union. They are so deadly and so easily spread, that the greatest precaution should be taken against them. The laws of many states forbid the selling of infested trees and require treatment of infested orchards.



SAN JOSÉ SCALE
Apple twig with scales on it,
slightly reduced

The scale may be killed by kerosene washes and sprays, or by a preparation of lime, salt, and sulphur. Badly-infested trees, especially peaches, plums, and other stone fruits, are not worth treating. They should be cut and burned.



Peach tree dying with San José scale

Insect Ravages.—These are only a few of our many insect pests. We are reminded of the boast of the locusts in the Eastern tale: “We are the army of the great God. We produce ninety-nine eggs. If the hundred were complete, we should consume the whole earth and all that is in it.”

Yet, vast and destructive as are the hosts, the farmer can protect his crops to a great extent against their ravages. He can do this in two ways, by cultural methods and by poisons. To use cultural means successfully, he must know the life history of the insects he is combating; to use poison successfully, he must know their structure and habits.

Cultural Methods.—The best means of controlling and checking most insects is by cultural methods.

The leaves, vines, and stubble in which and under which many insects winter should be destroyed. It is often wise to burn these on fields infested with chinch bugs and some other insects. The weeds on which injurious insects feed and breed should be destroyed as far as possible.

By deep fall plowing many insects are destroyed. Cutworms are brought to the surface and are frozen in winter; grasshopper eggs are buried so deep that the insects cannot come out.

Fertilizers give plants vigor to resist injury from insects, especially from root-feeding ones.

Insects collect on a trap crop which is planted early or at intervals in another crop. They can be destroyed before they attack the main crop.

The time of planting and cultivation can sometimes be planned so as to check insect enemies. Late-sowed wheat suffers least from the Hessian fly, early-maturing cotton largely escapes the boll weevil, late-planted corn is least injured by cutworms.

Other things being equal, two crops having the same troublesome insect enemies should not be placed side by side. Corn beside grass is more liable to cutworms; beside wheat, to chinch bugs.

Rotation of crops is an important means of protection against insect injury. In the case of many insects, it is the only practicable remedy. If land be planted in the same crop year after year, the soil becomes infested with insects injurious to it.

Insecticides. — The kind of poison used depends on the structure and feeding habits of the insect. As to feeding habits, insects may be divided into two classes, — chewing and sucking ones; the first have mouths arranged for chewing food, the second have mouth-tubes which they insert into a plant or animal and through which they suck its juices.

Chewing Insects. — Chewing insects usually live on the foliage of plants. They can be killed by applying to their food plants a poison, generally some form of arsenic. One of the cheapest and best forms is Paris green. The acid in it, like that in copper sulphate, needs to be counteracted by an alkali, and so with it also lime is used. Properly prepared and applied, Paris green is

harmless to most plants. Directions for its preparation and use are given in the appendix on page 307.

Of course external poisons are useless against chewing insects which live in fruits, such as the cotton boll weevil and cur cū'li o. Cultural and other methods must be used against these.

Sucking Insects. — Poison applied to the leaf surface is harmless to sucking insects also. We attack them in another way. Insects, as you remember, breathe through spiracles, openings in their abdomens. If these spiracles are closed, they perish for lack of air. Applications, such as prý'ěth rum powder or tobacco



APPLES GROWN ON TWO BRANCHES

On the left, apples from a branch sprayed for codling moth; on the right, apples from an unsprayed branch. This shows comparative quantity and quality of crops from the two branches.

dust, choke the breathing tubes. Sometimes sucking insects are killed by an application, such as lime, which destroys their body tissues.

Spraying. — Here is good advice about spraying: "Know the enemy to be destroyed; know the remedies that are most effective, and apply them at the proper season. Be prompt, thorough, and persistent."

EXERCISE

1. Compare a grasshopper, a moth or butterfly, a bug, a beetle, and a fly. In what ways are they like and in what unlike?

2. Collect some common insects. Watch their changes, and write an account of their life history from your own observation. To catch and keep insects, you need a net and a breeding jar. The net may be made by fastening a handle to a small hoop, and gathering to the hoop a cheese-cloth bag two or three feet long. The jar should have moist sand in the bottom and a cover of cheese cloth. Keep the insects in it supplied with fresh food, the foliage of the plants on which they are accustomed to feed.

3. Take two twigs infested with plant lice and two potato vines with beetles on them. Spray one of each with Paris green and dust one of each with lime. What is the effect in each case?



INSECT NET

INSECT FRIENDS

Helpful and Harmful Insects. — After man has done his utmost by cultural methods and poisons, it would be difficult if not impossible for him to keep the vast insect hosts in check. Fortunately, he has helpers in the animal world that do the greater part of the work. Among these are birds and insects.

It is not possible to make a hard-and-fast line between helpful and harmful insects. Some do good in one way and harm in another; some are friends under certain circumstances and foes under others.

Many insects are directly valuable on account of their products. The bee yields a palatable food, the silkworm a much-prized clothing material.

Insects are necessary to the well-being of many plants, to carry pollen and fertilize flowers. Some insects, even those that are annoying, are useful in destroying dead organic matter, such as decaying flesh and vegetables. Thus they purify the air and the soil, and change waste matter into plant food.

There are insects which we regard as our friends because they act as a check on injurious ones.

Ladybirds. — There are many beetles which live on other insects. The most useful of these are the ladybirds. There are only two or three injurious members in this large family. The ladybirds are small beetles with bright-colored wings usually spotted red and black. They live among the leaves of various kinds of plants. As larvæ and beetles, they feed on soft-bodied, injurious insects, such as plant lice and flies.



LADYBIRD BEETLES

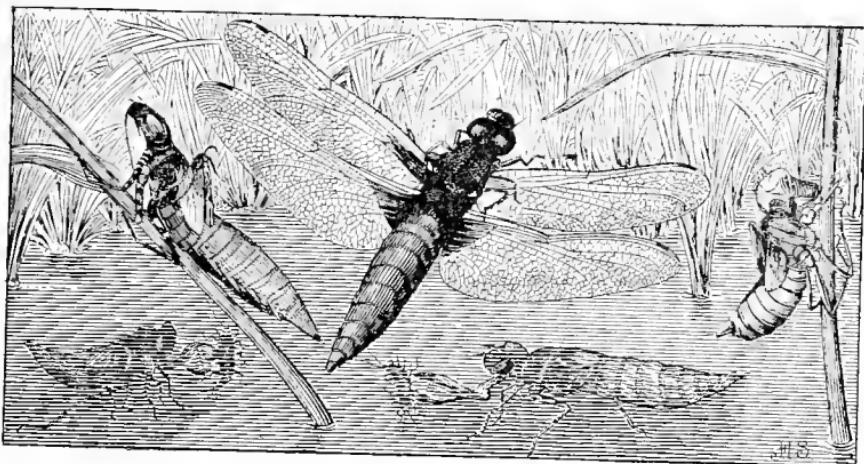
These ladybird beetles — the nine-spotted, the fifteen-spotted, the two-spotted, the twice-stabbed, and the pentilia — devour injurious insects.

Tiger and Ground Beetles. — There are hundreds of kinds of tiger and ground beetles, which devour many cutworms and caterpillars. The tiger beetles are rather bright-colored and active. They chase other insects, or lie in wait for them. Some of the ground beetles are shining black, others are marked with brilliant colors, — gold, green, and purple. They usually prowl after nightfall. Some of them climb trees in search of their prey.

Dragon Flies and Damsel Flies. — Dragon flies and damsel flies are graceful insects, with gauzy wings. They live near ponds and streams, and usually lay their eggs on the water. They feed on smaller insects, such as gnats, flies, and mosquitoes.

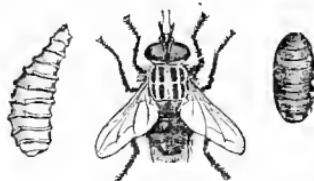
Ichneumon and Tachina Flies. — The ich neū'mon and tāch'i na flies destroy insects, not by feeding directly on them, but by utilizing them as food for their māg'gots, as the larvæ of flies are called.

These flies deposit their eggs on the larvæ of other insects. The maggots which hatch from the eggs enter the larvæ and destroy them by feeding on their juices.



DRAGON FLY, DIFFERENT STAGES

One kind of ichneumon fly locates the larvæ which are working as borers in trees. It makes a hole above them and deposits its eggs on them. Other kinds destroy tent-worm caterpillars, cabbage worms, and other injurious larvæ. From Spain there has been imported a fly which is the deadly enemy of the codling moth. It is a wasp-like fly, about five eighths of an inch in length, with two pairs of blue-black wings. It has a sharp, dagger-like sting with which it impales the larvæ.



TACHINA FLY

Larva at left and pupa at right

EXERCISE

1. Observe and describe helpful insects.
2. Catch some ladybird beetles and put them in a jar containing a twig infested with plant lice. What do the beetles do?

BIRDS

Birds' Food. — Some birds, such as barn swallows, live wholly on insects, most of which are harmful; some, such as bluebirds, eat both insects and seeds, chiefly weed seeds; others, such as

sparrows, live chiefly or entirely on weed seeds, fruit, and grain, but feed their young on insects until they are able to digest hard food.

In two ways birds are especially fitted for the work of destroying weed seeds and insects. They have keen eyes which can discover tiny seeds and insects; they have hearty appetites; it is no unusual thing for a bird to eat its own weight of food in a day.



Birds' services as weed seed and insect destroyers entitle them to be regarded by the farmer as among his most helpful friends. Too often they are not treated as such. Our beautiful and useful song birds are killed by hundreds and thousands for food or sport. What cruel and wicked slaughter! Let us do our part to protect and care for these bird friends.



INSECT- AND WEED-SEED-DESTROYING BIRDS
Bluebird, Tree Sparrow, Fox Sparrow, Robin

Bird Neighbors. — Song birds may be encouraged to nest about the yard, garden, and orchard. Their beauty and their sweet songs make them charming neighbors. It is a good plan to plant mulberries and berry- and seed-bearing shrubs near the house. Water should be put where birds can get it in dry weather, and food should be provided when the ground is covered with snow.

Useful Birds. — Among the birds most helpful to the farmer are the swallows, cuckoos, woodpeckers, sparrows, wrens, Baltimore oriole, bluebird, partridge, and mocking bird.

Swallows. — There are seven common species of swallows found in the United States, and most of them like to build their nests near houses. The barn swallow has given up its original habit of building in rock caves or under cliffs, and makes its nest under the eaves of barns or often inside barns and out-houses. Like all other insect-eating birds, swallows are swift of wing. They are rarely seen still, darting here and there to catch the flies, ants, beetles, and other insects which are their food.

Cuckoos. — Cuckoos eat grasshoppers and caterpillars, as well as flies and bugs. Unlike most other birds, cuckoos eat hairy cater-

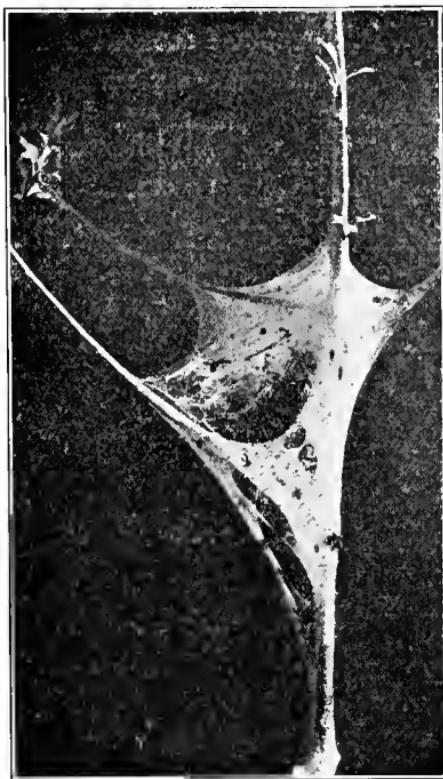


Courtesy of Connecticut Agricultural Station

A BIRDS' CHRISTMAS TREE

Chicadees are attracted to the bird house by food put on the shelf for them.

pillars, many of which are injurious to trees. Indeed, caterpillars of various kinds seem to be the chief article of their diet.



Courtesy of New Hampshire Agricultural Station

A caterpillar nest which has been attacked by birds

Woodpeckers.—Woodpeckers are the great friends of forest and fruit trees. They are sometimes accused of robbing the trees of sap; of only one is this true, the yellow-bellied woodpecker, or sap sucker. All other woodpeckers seek and eat the wood-boring larvæ. Some ants and other insects are very harmful to timber trees, often burrowing in them till the whole trunk is honeycombed. The woodpeckers, with their sharp bills, bore holes in the wood and draw the insects out on their tongues. Thus they destroy many insects which other birds cannot reach. They eat, also, grasshoppers, beetles, and other insects, and some small fruits and berries.

Sparrows.—There are many species of our native sparrows, and nearly all of them are farmers' friends. They are chiefly seed eaters, destroying great quantities of weed seeds. During the summer and in the breeding season, they eat insects, such as injurious beetles and small grasshoppers. All through the winter, they are busy reducing next year's crop of harmful weeds.

Baltimore Oriole.—The Baltimore oriole is one of our handsomest birds, and is a sweet singer as well as a useful insect-eater. Caterpillars form the largest part of its fare during its summer stay in our country. It eats other insects, including harmful plant lice, which are so small that they are searched out by few other birds. Less than one fifth of its food is vegetable, and that is wild fruit and seeds.

Wren.—The little house wrens are common in gardens and orchards. They live almost entirely on insects, such as grasshoppers, beetles, caterpillars, and bugs. Since practically all the insects they destroy are injurious, they should be encouraged to take up their residence near houses, by having nesting boxes provided. These should be fastened out of reach of cats.

Chickadee.—The chickadee is one of our tiny bird friends. It feeds on small insects, such as bark lice, and on insect eggs which escape the notice of most other birds.

Bluebird.—The pretty and common bluebird is another useful friend. About three fourths of its food is insects, chiefly grass-



Bluebird at edge of nest, with grasshopper in its mouth

hoppers and caterpillars. Its vegetable food consists mainly of weed seeds eaten in winter. It should be protected and encouraged to build near houses.

The birds mentioned are almost if not altogether harmless, but this is not the case with all our bird neighbors.

Robin and Catbird. — The catbird and the robin in its red-brown coat are familiar figures hopping about the yard or garden. Nearly one half of their food is made up of insects, chiefly harmful beetles, caterpillars, and grasshoppers. The remainder of their food consists of small fruits and berries. The fruit-grower complains especially of their thefts of berries and cherries. They are fond of mulberries, and many orchardists protect cherry trees by planting near them the Russian mulberry, as the fruit of both ripens about the same time.

Bobolink, or Rice Bird. — The bobolink is the northern name for a bird which is called rice bird in the South. It has a reputation in the two sections as different as its two names. In its summer sojourn in the North, it is welcomed as a song bird, which confines itself to a harmless diet of insects and weed seeds. It spends the winter in South America, going southward in great flocks in August and September. These flocks reach the southern states just as rice ripens. They pause to rest and feast on the grain before they take their long sea flight. It is estimated that they occasion rice-growers an annual loss of about two million dollars. Millions of rice birds are killed every year, but their numbers do not decrease, and the farmers are still seeking a remedy for the evil.

Red-winged Blackbird. — The red-winged, or swamp, blackbird is another instance of a bird that is harmful in one section and harmless in others. Usually it feeds chiefly on insects, such as weevils and beetles. But in the swamps and shallows of the upper Mississippi Valley there are bred immense flocks which do

great damage to the grain fields of the West. The young birds learn to fly just as grain begins to ripen, and the old birds lead them to the grain fields.

Crow. — In the East the crow has as bad a reputation as a grain eater as the red-winged blackbird has in the West. The Indians call the crow the 'thief of the cornfield.' It pulls up and eats seed corn that has been softened and sweetened by germination. The crow also attacks corn when the ear is soft, tearing open the husks and pecking the kernels. The ear thus exposed to the weather is often rotted by rain.

As a rule, however, crows destroy so many mice, grasshoppers, bugs, cutworms, and other crop enemies that they more than pay for the corn they eat.

Harmful Birds. — There are a few birds which do so much harm that it outweighs the good they do. Among these are the sharp-shinned hawk, Cooper's hawk, goshawk, and duck hawk. The first two destroy poultry, and all of them feed on game and insect-eating birds.

The greatest bird pest in the United States is the English sparrow. These sparrows were brought to this country from England about sixty years ago, with the expectation that they would destroy the insects on shade trees. Instead, they adopted a vegetable diet, doing much injury to grain and fruit buds and blossoms. They have increased enormously in numbers and have spread by millions all over the country.

English sparrows are noisy and quarrelsome, the enemies of many insect-eating birds, and they are pests around houses. The best method of destroying them is by poisoned grain exposed during the winter months on places out of reach of poultry.

EXERCISE

1. What birds are found in your locality all the year? Name some you see only in winter; only in summer.
2. What troublesome weeds and insects of your locality do birds aid in destroying?
3. Study the feeding and nesting habits of three common birds. Write an account of them based on your own observation.
4. Read Longfellow's poem, "The Birds of Killingworth."

OUTLINE OF CHAPTER SIX

DOMESTIC ANIMALS

Stock Raising:

Advantages:

Secures greatest profit from feeds and fodders

Retains in manure most of fertilizing value

Animals need:

Proper food

Pure water

Good shelter

Pure air

Kind treatment

Animal food consists of:

Water

Protein, or nitrogenous compounds

Fats, or oils

Carbohydrates, or starchy and sugary substances

Ash, or mineral matter

Food supplies material:

For heat

To repair waste of system

For force or energy

For growth and fattening

Kinds of food:

Bulky foods, fodders, roughage, and forage:

Stems, branches, leaves, and roots of plants

Concentrated foods or feeds:

Seeds

Balanced and unbalanced rations

Rules for feeding:

Feed animals all they eat with relish and without waste

Feed a balanced ration

Give food of bulk adapted to animal's stomach

Give variety of food

Feed regularly

Pasturing and soiling systems

Cattle:

Products:

Milk, cream, butter, cheese, veal, beef, leather, etc.

Beef breeds:

Shorthorn, Hereford, Galloway, Aberdeen or Polled Angus, etc.

Dairy breeds:

Milk breeds:

Ayrshire, Holstein-Frisian, etc.

Butter breeds:

Jersey, Guernsey, etc.

General-purpose breeds:

Shorthorn or Durham, Hereford, Devon, Red Polled, etc.

Butter making

Some diseases of cattle:

Tuberculosis

Tick, or Texas, fever

Horses:

Uses:

Riding, driving, pulling, and hauling

Draft breeds:

Percheron, Clydesdale, mules, etc.

Light horses or roadsters:

Thoroughbreds, trotting horses, saddlers, carriage or coach horses,
ponies

Shoeing, checkrein, docking

Sheep:

Products:

Lamb, mutton, wool, leather

Fine wool breeds:

Merino, etc.

Mutton breeds:

Southdown, Shropshire, Hampshire, Dorset, Leicester, Oxford,
etc.

Some diseases of sheep:

Fly, foot rot, scab

Goats:

Products:

Milk, cheese, hair, mutton, leather

Chief breeds:

Malta, Angora

Hogs:

Products:

Lard, meat, leather, etc.

American breeds:

Chester White, Poland China, Duroc Jersey or Jersey Red, etc.

English breeds:

Yorkshire, Berkshire, Tamworth, Essex, etc.

Chief disease:

Cholera

Poultry:

Products:

Eggs, meat

Hens:

Egg breeds:

Leghorns, Houdans, Minorca, Spanish, etc.

Meat breeds:

Brahma, Cochin, Langshan, Game, etc.

General-purpose breeds:

Orpington, Plymouth Rock, Wyandotte, Rhode Island Red, etc.

Ducks, turkeys, geese, guinea fowls, peafowls, pigeons

Food, quarters, diseases

Bees:

Uses:

Honey, pollen carrying

Breeds:

Native brown or black, Cyprian, Italian, Corniolan, Caucasian, etc.

Queen, drones, workers

Beekeeping



AT THE WATER TROUGH

CHAPTER SIX

DOMESTIC ANIMALS

STOCK RAISING

Indian Farming. — Three hundred years ago the plains and forests of this vast country were dotted here and there with the farms, or patches, of Indians. These were usually little spots of mellow soil. Indian women stirred the surface with crooked sticks, buried seed corn in the soil thus prepared, and with the aid of children pulled up weeds, frightened away 'robber crows,' and gathered the ripe grain.

In addition to the patch of corn there were, perhaps, others of tobacco and beans; these, also, the women and children cultivated by hand. The North American Indians kept no domestic animals, — horses, mules, oxen, cows, hogs, sheep, or poultry.

Domestic Animals. — Very different are the vast and productive farms which have succeeded the Indian patches. Our system of farming depends largely on the use of domestic animals; over one third the value of the farms of the United States is in the stock kept on them. Horses, mules, and oxen cultivate the crops and do the hauling. Cows supply milk, butter, and beef; sheep furnish lamb and mutton, as well as wool; hogs yield pork and lard; fowls give eggs and chickens; bees provide honey.

The farmer who lacks these animals on his farm is apt to lack their products on his table. Even when markets are convenient,

it is usually less expensive and more desirable to raise them than to buy them.

Animal Products. — It is often not only desirable to raise these products for home use but profitable to raise them for sale. There is a large and constant demand for milk, cream, butter, cheese, beef, eggs, chickens, turkeys, lard, pork, bacon, honey, lamb, mutton, wool, and leather.

Why Stock Raising Pays. — As a rule, farms and farmers are richer when stock farming is practiced. Stock farming makes larger returns in dollars and cents for the amount of fertility taken from the soil than does any other branch of farming.

On every farm there are feeds and fodders which it pays better to feed to stock than to use in any other way. Hay, fodder, and other bulky foods are expensive to handle and have a comparatively low market value. It is easier to handle and market 'corn on the hoof,' as cattle and hogs, than corn on the cob. Changed into more concentrated forms, such as wool, milk, and butter, farm products are still more conveniently marketed and command higher prices.

The good farmer receives these higher prices, and yet retains the larger part of the value of the food consumed by domestic animals. Only a small part of the fertilizing elements of their food is used in making bone, muscle, flesh, and products. The larger part is returned to the land in manure.

To make a success of stock raising, one must be interested in animals and in their growth and improvement, must understand their needs, must care for them well, and must feed them intelligently so as to make the greatest gains at the least expense. Profit in stock raising, as in crop raising, lies in producing the most and the best at least expense.

Care of Animals. — Animals require much care and attention in different ways. They need an abundance of proper food and pure

water. They need pure air, but they need also protection against wind and rain, cold and heat. Therefore they should have clean, dry, comfortable quarters.

Stock should be kept clean, free from ticks and lice, and sick ones should be separated from well ones. Care should be taken to keep the water supply pure, as disease is often caused and spread by impure water. It should always be borne in mind that 'an ounce of prevention is worth a pound of cure.' Usually, animals that have good care, proper food, and pure water are in vigorous health.

Animals should be kindly treated. 'It is true of them as of men that it is worry not work which kills.' Some men take many dollars out of their own pockets every year by neglect or ill treatment of their stock. Neglected, poorly fed, ill-used animals are stunted in growth and stinted in products. Naturally they are unprofitable.

Breeds. — There are some animals that do not repay even good attention. As it costs no more in care and feed to keep good stock than bad, a farmer should try to secure the best. He should select the breeds best adapted to his special purposes, — production of wool or mutton, beef or milk, eggs or chickens, etc.

It is usually economical to pay higher prices and secure pure-bred animals, — that is, those in which the traits desired have by heredity and selection become fixed as habits. Some farmers prefer high-grade stock, a cross between common stock and pure-bred; it is usually hardier than pure-bred and less subject to disease. A pure-bred sire at the head of a flock or herd will add greatly to the value of common stock.

Whether pure-bred or grade stock be used, inferior specimens should be sold or slaughtered, and food and care given to animals which make the best returns for them.

The kind and quantity of food given animals is a matter of so much importance that there is a saying that 'feed makes breed.'

We have learned something about crop feeding; let us now consider the subject of stock feeding.

Soil and Plant. — You have already learned that processes in the soil prepare elements for plant use, changing unavailable ones into available forms. Then the plant changes these inorganic elements, gases and minerals, into organic structure, corn, clover, cotton, — according to its nature.

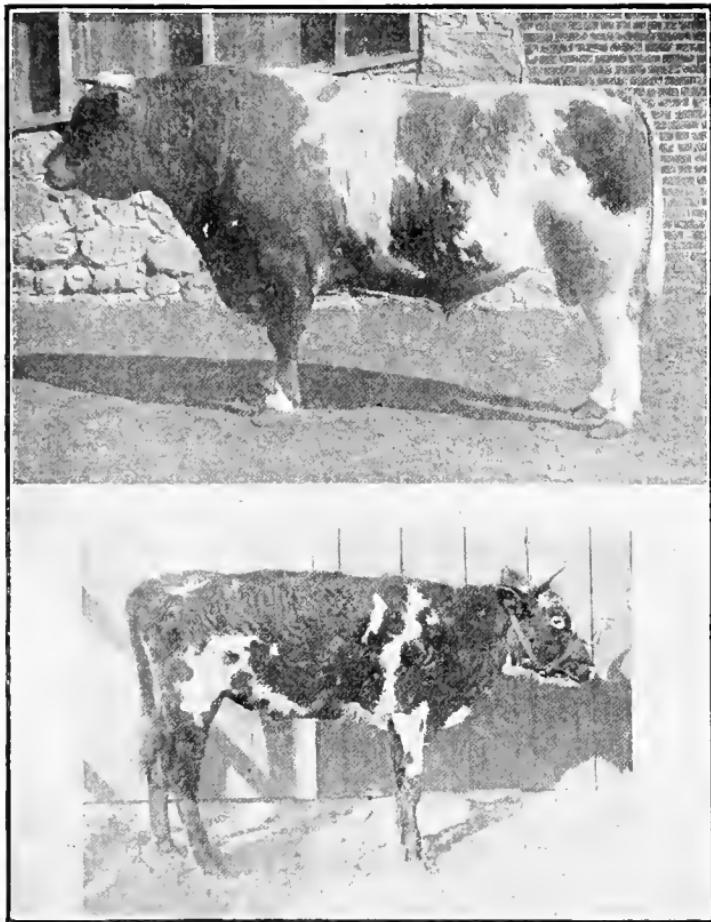
Plant and Animal. — The plant changes substances into prō'tein or compounds containing nitrogen, into fat or oils, and into starchy and sugary compounds called car bo hȳ'drates. In addition to these, the plant contains water and ash or mineral matter. The animal body is made up of similar substances, for all of which, except water, animals are dependent on food furnished directly or indirectly by plants.

As the soil processes prepare elements for the plant, so the plant prepares them for the animal. Corn and clover, hay and grain, are changed by the animal into blood, flesh, and bone.

Food Assimilation. — The process begins in the mouth. There the food is chewed and mixed with saliva. It passes through the stomach and the intestines, where it is subjected to the action of various juices; food thus acted on is said to be 'digested.' This digested food passes through tiny tubes, called lăc'te als, into the blood vessels. As the sap carries nourishment to the plant, the blood carries nourishment to the animal and in a wonderful way not clearly understood by us makes flesh and bone. The undigested part of the food passes from the system through the kidneys and bowels.

Uses of Food. — Let us consider the uses of food to animals.

First: Food supplies material to repair the waste of the system;



Courtesy of Michigan Agricultural Station

THOROUGHBRED AND SCRUB CATTLE

These two head of cattle are of the same age, and have had the same care and food. Which does it pay to raise?

Just as a fire needs fuel to keep it going, the animal needs food to keep it alive. Every beat of the heart, every movement of the body, wears out tissue, and the old particles must be replaced by new. This change goes on gradually but so constantly that all particles in the body — except, it is believed, the enamel of the teeth — are replaced by new particles. This new tissue is formed by nourishment which comes from the food. Protein is a flesh former or tissue builder. It forms muscles, nerve tissue, brains, bone, skin, hair, wool, nails, hoofs, and the solid white substance of the blood. The ash forms ash, giving firmness to bones and teeth.

Second: Food supplies heat. In summer or winter the temperature of the body must be kept at about 98°. Body heat is kept up chiefly by carbohydrates. Fats serve the same purpose, one pound of fat being equal in feeding value to two and two fifths pounds of carbohydrates. More of this class of food is required to keep the body at the proper temperature in winter than in summer, in cold countries than in warm ones. In winter people eat more meat, hogs and horses more corn, because these are carbo-naceous, or heat-supplying foods. When animals are kept in warm stables in winter, it requires less food to keep up body heat.

Third: Food supplies force or energy. This also is supplied largely by fats and carbohydrates. Every furrow the horse plows, every pound it pulls, every step an animal takes in exercise or in search of food, requires energy. Horses at hard work require more food than those at light work and much more than those that are idle. Even on larger rations, horses are apt to lose flesh during the hard-working spring season.

Fourth: Food supplies material for growth and fattening. Fat and carbohydrates, often called fat formers, form fat but do not build up tissue. Young growing animals and animals producing

milk and eggs need flesh formers, or foods containing nitrogen. Fattening animals require more carbonaceous foods. The smaller the demand for heat and energy, the more food can go to forming fat. Therefore it is more economical to fatten and kill hogs before cold weather when much of their food would be used to furnish heat. It is wise to pen fattening hogs and to confine fattening cattle in stables or feed lots so that food may go to fat instead of to energy.

Kinds of Food. — There are two kinds of food commonly used for stock, bulky foods called forage, roughage, or fodders, and concentrated foods or feeds.

Forage. — The bulky foods most commonly used are hay, cornstalks, straw, silage, roots, and tubers. As a rule, fodders are rich in carbohydrates and poor in protein. They differ greatly, however, and the difference is due not only to the kind of plant, but also to soil, time of cutting, and method of curing.

Feeds. — Feeds are seeds of plants, whole or ground, and their by-products. Feeds supply protein, fat, and carbohydrates, and furnish a large amount of nourishment in small bulk. Grain—the seeds of cereals, such as corn, rye, oats, and barley — is largely used for feeds.

Other valuable feeds are the seeds of peas, beans, and other legumes; mill feeds, the ground grain of cereals; bran and middlings, the germs and the outer coverings of grain; cotton-seed meal, left from the manufacture of oil from cotton seed; linsced meal, or oil meal, left from the manufacture of oil from flax-seed.

Food Value. — A food is valuable according to its digestible value. This depends to a great extent on the form in which it is fed. The fiber of cornstalks and other coarse fodders resists the digestive fluids. To get their full feeding value, these should be

cut or crushed. Some seeds, such as corn, that have hard shells have their food value increased by grinding.

Scientists made laboratory tests to learn the chemical value of foods, and feeding tests to learn their digestible value. They weighed and analyzed the food, products, and manure of animals to learn how much food was digested. Experiments long and carefully conducted enabled them to prepare tables showing the feeding values of different foods and fodders,— that is, their amount of digestible protein, fat, carbohydrates, and ash. A table containing a statement of some of these results will be found on page 309.

Every farmer bears practical testimony to the truth of these tests by the different prices he sets on different feeds and fodders, and the way he feeds and buys and sells. As a rule, the richer a food is in nitrogen the greater its value.

Feeding Standards. — Scientists made feeding tests also to learn the amount of digestible protein, fat, and carbohydrates that are best for domestic animals under average conditions. They studied the results of different foods and different amounts on thousands of animals. The results are embodied in what are called 'feeding standards' (see page 309). These tell the proper ration, or one day's food, for an animal of a certain weight under ordinary conditions.

A ration conforming to this standard and giving the proper amount of digestible protein, fat, and carbohydrates is called a 'balanced ration.' Feeding standards are not hard-and-fast rules, for there are differences among individuals, but they are good general guides.

As you have learned, food has a twofold value, its feeding value and its manurial value. This latter subject has been discussed in the chapter on *Soil Improvement*.

Balanced and Unbalanced Rations. — Practical tests show that animals generally thrive better when the ration is properly balanced. A balanced ration is more economical for the farmer as well as better for the animal; there is always waste in an unbalanced one. If, for instance, an animal be fed a ration too high in carbohydrates and too low in protein, it will consume more carbohydrates than it needs in order to obtain enough protein.

Sometimes special conditions, such as the feed on hand and market values, make it necessary or desirable for the farmer to feed an unbalanced ration. This should, however, be guarded against as far as possible. It is often cheaper to sell some feeds and buy others than to feed unbalanced rations. Many farmers feed carbonaceous foods, especially corn, in wasteful excess; it would be better to sell a part of the corn and purchase some feed richer in protein, such as linseed meal. At less cost animals would thrive better. Hogs fed entirely on corn-meal sometimes lose the use of their legs for want of bone-forming food.

Food. — The amount and kind of food to be given differ according to the purpose of feeding. Usually, food is given to animals not merely to keep them alive but to supply energy for work, to make them grow, to fatten them for food or market, to provide products such as milk and eggs.

Rules for Feeding. — Here are some rules which practical farmers find it profitable to follow.

First: Animals should be fed as much as they will eat with relish and without waste, and digest well. This gives best returns in growth, fat, and products. 'Stunted animals are usually stunted ones.' Overfeeding is injurious as well as wasteful. Too much unripe grain, green rape, cowpeas, clover, or alfalfa may cause sickness or death.

Second: Animals should be fed a balanced ration in order to

supply all the needs of their systems. Fat and carbohydrates are needed to supply heat and force, fat and milk; protein to form flesh, to build up waste tissue and to form new.

Third: The food must have a certain bulk adapted to the size of the animal's stomach and the length of the intestines. Ruminants, such as the cow and sheep, need two thirds bulky food, such as hay and straw; horses need half fodder and half grain; pigs and poultry need more than half concentrated food.

Fourth: Animals, like people, need variety of food. Change of rations improves appetite and digestion. Decided change in kind or amount of food should be made gradually, not abruptly.

Fifth: Animals should be fed at regular hours. Like human beings, they thrive better when their meals are given at proper fixed times.

Raising Feed. — As a rule, a farmer should raise most or all of his own fodders and feeds. He should choose productive and nourishing ones which are suited to his soil and climate and which supply a balanced ration.

Pasturing and Soiling. — Where land is cheap and farmers practice the extensive system, trying to cultivate as many acres as possible, it is usual to graze stock. This is the common method in the South, where, with a little attention, fields and pastures furnish stock a bountiful living three hundred out of three hundred and sixty-five days in the year. It is also the rule on the great western ranges, rich in nutritious native grasses.

Where land values are high, farmers practice the intensive system, trying to raise as large crops as possible on each acre. There, soiling is preferred,— that is, animals are kept in stables or yards and fed cut forage.

One acre in soiling crops has as much feeding value as four acres in pasture. A fifteen-acre dairy farm in Pennsylvania by the soil-

ing system for years supported thirty Jersey cows, two to the acre. Grazing animals trample and destroy more than they eat. The manure is unequally distributed, leaving part of the land unfertilized and causing part to produce rank growth which stock avoid. When such crops as alfalfa, drilled corn, oats, vetches, rye, and clovers are cut and fed to cattle, their full value is utilized as food and as manure. Cows are often more comfortable in good stables than in pastures where flies annoy them.

On many farms there are woodland or meadow pastures unavailable for crops, which it is economical to use for pastures. These will often be found more profitable when supplemented by soiling crops.

EXERCISE

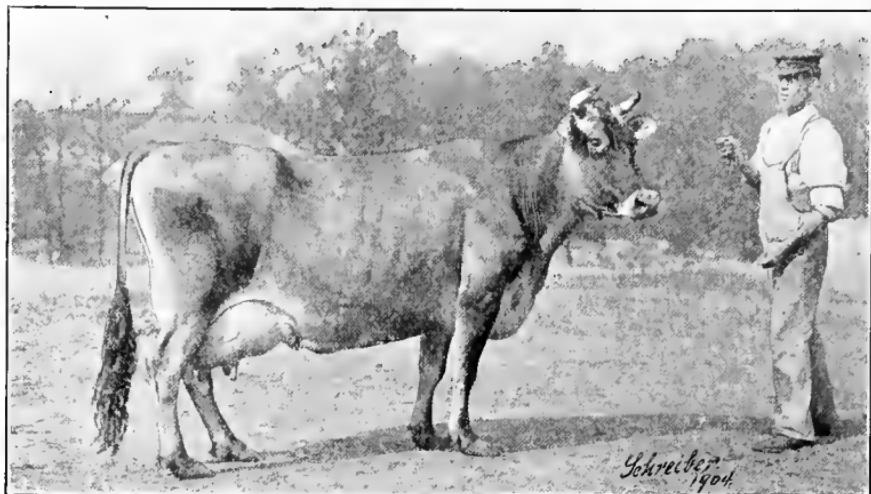
1. Do you know any domestic animal that is fed a balanced ration? an unbalanced one? What is the condition of each?
2. Name three stock foods rich in protein; three rich in carbohydrates.
3. In your locality, which is more profitable, pasturing or soiling? Give reasons.

CATTLE

History. — Formerly all farm animals were called cattle. Now the term is applied only to beef and dairy breeds. Our tame breeds are descended from the wild cattle of Europe and Asia; most of the improved ones have been developed in Great Britain. They have had their milk and flesh capacity developed by food, care, and selection.

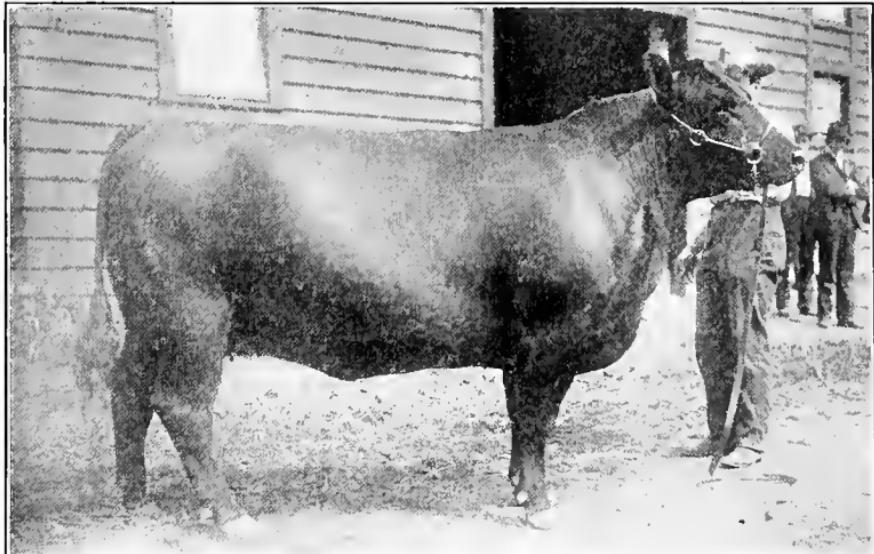
Cattle are raised chiefly for beef, veal, milk, cream, butter, and cheese; but they furnish us other things. Their hides are valuable for leather, their hair for plaster, their hoofs for glue, their bones for buttons and fertilizers.

Beef and Dairy Breeds. — Cattle may be divided into two great



LOREITA D — A DAIRY TYPE

A pure-bred Jersey; the champion dairy cow at the St. Louis World's Fair in 1904. Her record for 120 days was 5802.7 lb. milk, yielding 330.03 lb. butter.



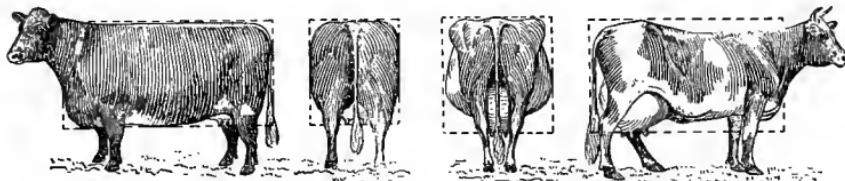
BLACKBIRD 26TH — A BEEF TYPE

An Aberdeen-Angus cow, weighing 1800 lb., champion of St. Louis World's Fair, 1904.

classes, the beef breeds used chiefly for flesh or beef, and the dairy breeds raised chiefly for the production of milk, butter, and cheese. The two types differ much in appearance.

The beef breeds are large, square-built, compact, and broad-backed. Their food goes to fat. Among the principal beef breeds are Shorthorn, Hereford, Galloway, and Aberdeen or Polled Angus. The raising of beef cattle is one of the chief industries on the western plains. Vast herds thrive on natural grasses and require little care.

Dairy Cattle. — The dairy breeds are small and wedge-shaped. They have little flesh on the back, loins, and thighs, but the hind



REAR AND SIDE VIEWS OF DAIRY AND BEEF CATTLE, SHOWING DIFFERENCE IN SHAPE

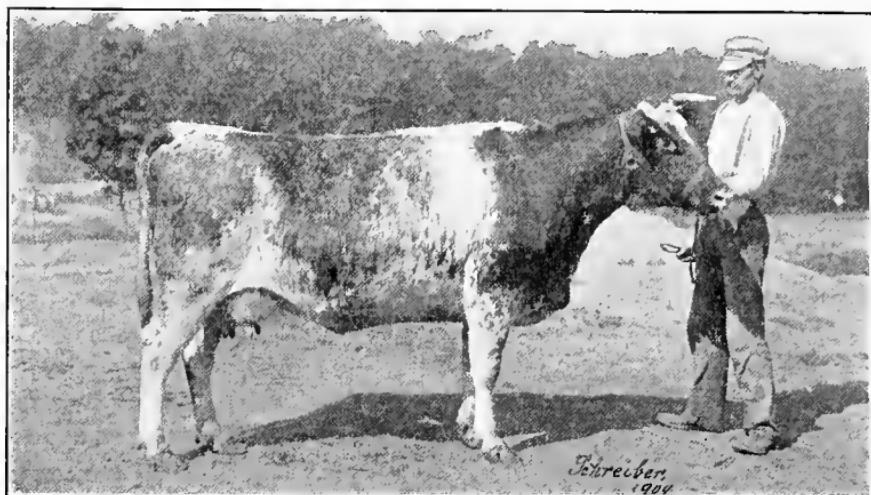
parts are deep and wide. They have large stomachs and udders with large many-branched milk veins. Their food goes to milk. In the eastern part of the United States, chiefly dairy breeds are kept.

Dairy cattle are subdivided into milk breeds, which give a large quantity of milk, and butter breeds, which yield milk rich in butter fat.

Milk Breeds. — Among the chief milk breeds are the Ayrshire from Scotland and the Holstein-Frisian, a Dutch breed.

Butter Breeds. — The best butter breeds are the Jersey and the Guernsey, which originated on the islands of the same name in the English Channel. Our common cattle are improved in butter-producing qualities by a cross with Jerseys or Guernseys.

General-purpose Breeds. — There are some breeds called general-purpose cattle, which are valuable for both milk and beef. Among these are certain strains of the Shorthorn or Durham, the Devon, and Red Polled. The range cattle of Texas and the West have been graded up chiefly with the Shorthorn and Hereford.



ROWENA 2ND — DUAL-PURPOSE COW

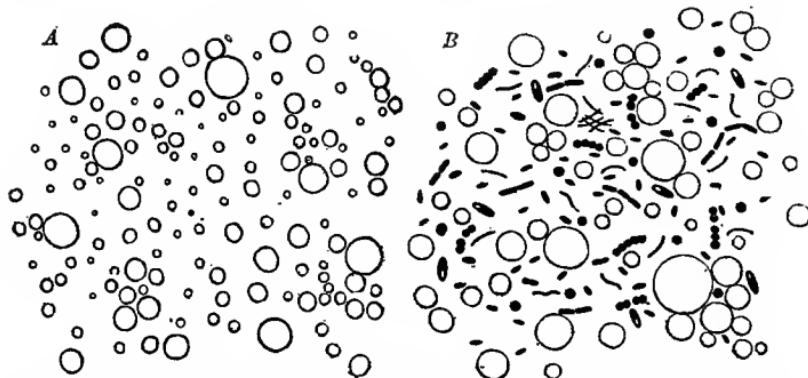
A pure-bred Shorthorn, champion dual-purpose cow of the St. Louis World's Fair in 1904. Her record for 120 days was 4053 lb. milk, yielding 201.13 lb. butter: during that time she gained 139 lb. in weight.

Improving 'Scrub' Cattle. — Common or 'scrub' cattle, as a rule, mature slowly and give less flesh and milk for the same amount of food than do improved breeds. The quickest and most economical way to improve a herd of common cattle is to put at the head a bull of the type desired. It is often and truly said, "the sire is half the herd." Some breeds, such as the Shorthorn, transmit their good qualities with especial strength and certainty.

Dairy Products. — Dairy products are milk, cream, butter, and

cheese; the by-products are skim milk, buttermilk, and whey. Milk is a fluid formed in the glands of the cow's udder. It is an ideal food, containing in readily digestible form water for thirst, ash to make bones, protein to form flesh and muscle, and fat and sugar to supply heat and energy.

The globules of fat are light and rise to the surface, forming cream. These globules vary in size. They are large in the



A, PURE MILK, AND B, IMPURE MILK, AS SEEN UNDER THE MICROSCOPE

A shows fat globules; *B* shows globules and also many forms of bacteria. *B* stood several hours in a warm room in a dirty dish.

milk of the butter breeds and small in that of the cheese breeds.

Bacteria, always present in the air, grow in milk and change its sugar to an acid which gives it a sour taste. Where strict cleanliness is observed, there are fewer bacteria and milk does not sour so quickly. Souring, or turning, of milk is retarded also by keeping it cool, as bacteria thrive in warmth. Cooling milk does not destroy the germs but only checks their action.

Skim milk and buttermilk, from which fat has been removed, and whey, left from the manufacture of cheese, are wholesome and

nourishing foods for human beings and for live stock, especially pigs, calves, and poultry.

The profitableness of a dairy cow depends on the quality and quantity of her milk. The amount of butter fat in milk can be determined exactly by the Babcock milk tester, a simple machine invented by Dr. S. M. Babcock of Wisconsin, which is used by dairymen all over the country.

On dairy farms the cream is taken from the milk by a machine called a separator which does the work better and more quickly than it can be done by hand. The cost of separators often prevents their being used on small farms, and there the milk is set in pans for the cream to rise.

After the cream ripens or sours, it is churned, to collect the butter fat in compact shape. The proper temperature for cream for churning is from 58° to 62°. If it is too warm, ice or cold water should be added to bring it to the proper temperature; if it is too cold, it should be warmed by placing the can containing it in a larger vessel containing hot water. The butter must be washed with cold water to harden it, and then salted with fine dairy salt.

The process of making good butter ends with churning, but it begins with the care of the cow, milk, and cream. The cow's food affects the color, flavor, and texture of the butter. Most of the bacteria are destroyed in butter, probably by the salt. Some remain, and it is the action of these which makes it become rancid with age.

The production of cheese is much more complicated than that of butter. It is attended to chiefly in cheese factories.

Care of the Cow. — The cow should have an abundance of pure water, salt always in reach, and plenty of good wholesome food. Like all other animals, she needs a balanced ration. An average

cow should have six times as much carbohydrates as protein. This is usually expressed in the form of a ratio, one to six, or 1 : 6, called the 'nū'tri tive ratio.'

As a cow's stomach is large, she needs much bulky food, about twenty-seven pounds of dry matter in a ration. In winter she should have good hay, and in summer soiling or pasturage should provide green forage. Turnips and other root crops should be fed chopped or sliced. They should be given directly after milking so as not to injure the flavor of the milk.

Filth injures the quality of all dairy products. Cleanliness, fresh air, dryness, and sunshine kill bacteria which injure the health of the cow and affect her products. The stable should be clean, comfortable, and well ventilated. The cow's udder and the body near it should be washed, and milking should be done with clean dry hands.

Milk should never be left standing in a stable or milkroom, where the air is impure. It readily absorbs flavors and should not be kept near cabbage, onions, or any other highly-flavored foods. All vessels used about milk should be washed in cold water and then scalded with boiling water. They should often be sunned and aired. 'Cleanliness should be the watchword of the dairy.'

The cow should be fed and milked at regular hours and always treated with kindness. She is a nervous animal, and tests show that the quality and quantity of her milk are injured by rough, harsh treatment.

Diseases. *Tuberculosis.* — The most common and dangerous disease of dairy cattle is tu ber cu lō'sis. It is caused by bacteria in the affected part of the body; these form tubercles, swollen masses of tissue, which finally break down into a cheesy mass. Some scientists say that the disease can be communicated to human beings from the milk and the flesh of diseased animals. By boiling

the milk or flesh, the harmful bacteria are destroyed. The tendency to tuberculosis is increased by anything that weakens the general health of the animal, such as overcrowding in foul, badly-aired stables, feeding bad food, and overproduction of milk and young. The disease is contagious, and animals affected with it



SHORTHORN STEERS

The steers in this car-load lot averaged 1544 lb. in weight; they were prize winners at a Texas Fat Stock Show.

should never be kept in a stable or herd with healthy ones. Badly diseased cattle should be killed.

Tick Fever. — Tick, or Texas, fever, prevails south of Maryland from the Atlantic to the Pacific. It is caused by a parasite, conveyed by cattle ticks, which are parasites of the southern United States. A tick cannot mature except on an animal. It fixes itself on the skin of cattle at pasture; when full-grown, it drops off and lays its eggs — fifteen to twenty-five hundred — on the grass. If the young ticks which hatch out fail to fix themselves on animals, they die in a few months.

Southern cattle are rendered immune, or not subject to the disease, by being exposed when young; but the fever kills during the first summer most of the mature cattle carried from northern to southern states. It is communicated by ticks dropped from southern cattle carried north in the summer. Healthy herds sicken and die if driven across the trail where infested herds passed one, two, or three months before.

Tick fever is a serious drawback to introducing improved breeds in the South and has caused strict laws to be passed about the summer marketing of southern cattle. The fever can be prevented by cleaning cattle and pastures of ticks. They can be removed from cattle by the use of kerosene and other oils. Pastures can be cleaned by keeping cattle off an infected field for several months, usually from the first of April till the first of September.

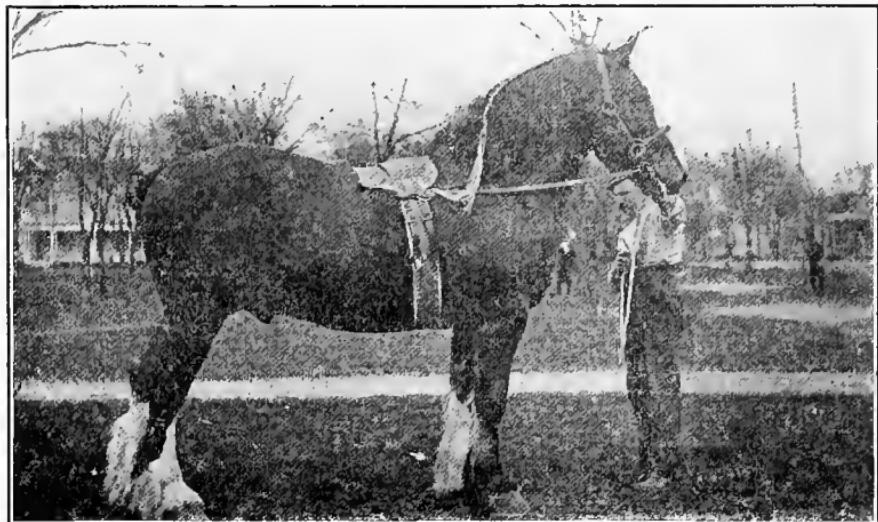
Cattle are inoculated against tick fever, just as people are against smallpox.

EXERCISE

1. Are the cattle of your locality chiefly beef or dairy breeds? Name three points in proof of your statement. What breeds are most profitable in your section? Why?
2. Make a balanced ration for a dairy cow, using corn, fodder, alfalfa, and cotton-seed meal.
3. A farmer raises corn and timothy hay. What should he sell and what buy in order to furnish balanced rations for dairy cattle?
4. Take two milk bottles; wash and scald one and cool it with pure water; rinse the other out with sour milk. Put sweet milk in both and seal them. Open and examine at regular intervals. In which bottle does milk sour first? Why?

HORSES

History. — Our horses are descended from wild horses, such as are found to-day in many parts of the world. They have been improved by care, food, and selection for over three thousand years, and have been trained to artificial gaits, such as the trot and



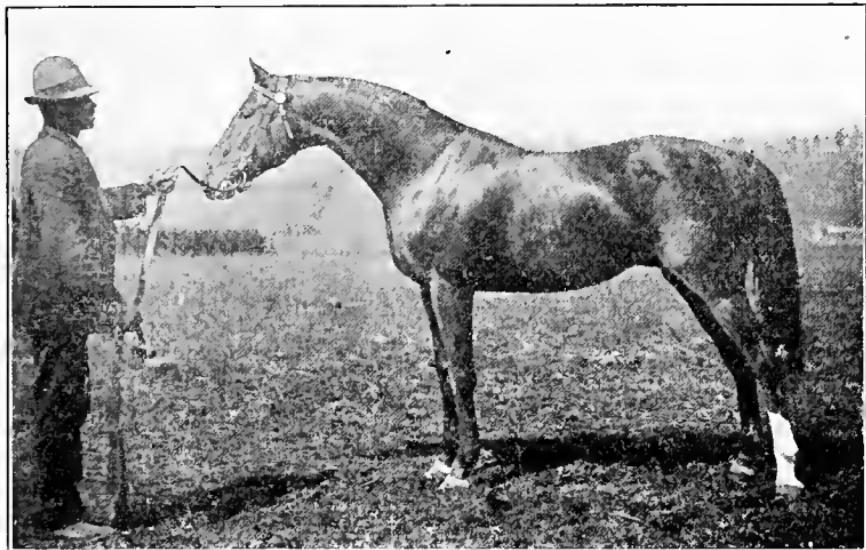
BARON DOUNE, A PURE-BRED CLYDESDALE

A good type of draft horse, weighing about 2000 lb.

pace. Their natural gaits are the walk and the gallop. Horses are not natives of America. Our wild ones are descended from those brought over by the Spanish and French discoverers.

* **Classes.** — There are many breeds of horses, but they may be roughly divided into two classes: draft horses, the heavy horses used for farm work and hauling; and light horses, or roadsters, used for riding and driving.

Draft Horses.—Draft horses are large, usually weighing from fifteen hundred to two thousand pounds. They have broad backs, short legs, and upright shoulders that give an easy support to the collar. The best breeds of draft horses have been developed in Belgium, France, England, and Scotland. Two well-known



ORNAMENT, A KENTUCKY THOROUGHBRED

Selected by Kentucky horsemen as a type of the breed

breeds are the Percheron from France, and the Clydesdale from Scotland.

Light Horses.—Light horses, or roadsters, are much smaller than draft horses. They are light of bone and muscle, have long legs, long thin necks, and sloping shoulders. Thoroughbreds, the English running horses, are descended from the Arabian steeds which are noted for speed, courage, endurance, and intelligence.

The trotting horse developed in America is not recognized as a

distinct breed, but is better known than most pure breeds. The saddle horses of Kentucky and Virginia are well known. Among the best carriage or coach horses are the Cleveland Bay, the French Coach, and the English Hackney. Hackneys are large, active, and stylish, adapted to both road and farm work. Small horses are not adapted to the deep plowing, hard pulling, and heavy hauling of the farm.

Pure-bred sires improve common stock. It is profitable to breed and use good grades.

Ponies. — Ponies are breeds of small horses. The gentle, shaggy, little Shetland ponies from the Shetland Islands off the west coast of Scotland are favorites with children. The Indian ponies and mustangs of the West, North, and South are descended from the horses brought to this country from Spain and France. They are active, hardy, and much prized as saddle horses.

Mules. — Mules, a cross between the horse and the ass, are noted for strength, endurance, and hardiness. They are valuable for farm purposes and for heavy hauling.

Food. — Grass is the natural food of the horse, but an entire diet of it makes a horse 'soft' and unfit for hard work. The best foods are good hay, oats, and corn. A horse needs about twenty pounds of dry matter daily; half of the food should be a concentrated feed, such as corn, and half a bulky food, such as hay.

A horse needs about eight gallons of water a day and should be watered three times a day, before meals. At work in warm weather, horses, like people, need water oftener, but are apt to be injured by drinking much cold water when they are very warm.

Care. — The horse should be given clean, comfortable quarters, gentle, firm management, and good feed. Good treatment will do much to give horses a good disposition. They are nervous animals, and rough, harsh treatment makes them vicious and

unreliable. Good grooming keeps the pores of the skin open and the hair glossy and in good condition.

Probably no animal suffers so much from the cruelty, neglect, and ignorance of its owner as does the horse. It is often driven, worked, and fed with little judgment, its health injured, and its period of usefulness is lessened or cut short by neglect and mismanagement. Bad treatment does not stop here. It is often subjected to mutilation which injures it permanently.

Shoeing. — Probably the most frequent and serious injury comes from bad shoeing. There is an old saying, "No foot no horse." The general purpose of shoeing is to preserve the exposed hoof from wear. Farm horses and horses not compelled to do heavy work on hard roads would be better off if never shod at all. When they are shod, the hoof loses its natural moisture. The horse is apt to go lame if the shoes are removed, unless it is kept in pasture until the hoof regains its natural condition.

The frog is a natural cushion of gristle to lessen the shock of travel. It should never be trimmed nor touched with the knife. The horny wall should be interfered with as little as possible. The outside is covered with a natural varnish which should never be cut nor rasped off. Only the portion of the wall and sole on which the shoe rests should be touched. From this should be trimmed or rasped the portion which the shoe prevents from wearing off as it would naturally do on the unshod hoof. The hoof should be levelled carefully and the shoe made to fit the foot, not, as is too often done by ignorant blacksmiths, the foot made to fit the shoe.

Checkrein. — A checkrein is a discomfort and disadvantage to a horse. Think how uncomfortable it would be for you to have your head fastened up in the same position for hours at a time! The checkrein deprives the horse of the power of throwing its

weight forward to pull a load. If a checkrein be used at all, it should not be tight, and it should be let down in pulling a heavy load or going uphill.

Docking. — The horse's tail should never be docked. This is its fly brush and protection against enemies. When it is docked, the horse is made 'a life pasture for annoying insects.'

EXERCISE

1. Have you read "Black Beauty"? If not, do so. It is an interesting story of horse life, giving valuable suggestions as to care and treatment.
2. Compare the best draft horse with the best light horse that you know. Make a list of the points of difference. Name three occasions on which you would prefer the light horse. Why? Name three on which you would prefer the draft horse. Why?
3. From the table on page 309 in the appendix make a balanced ration for a work horse weighing fifteen hundred pounds.

SHEEP

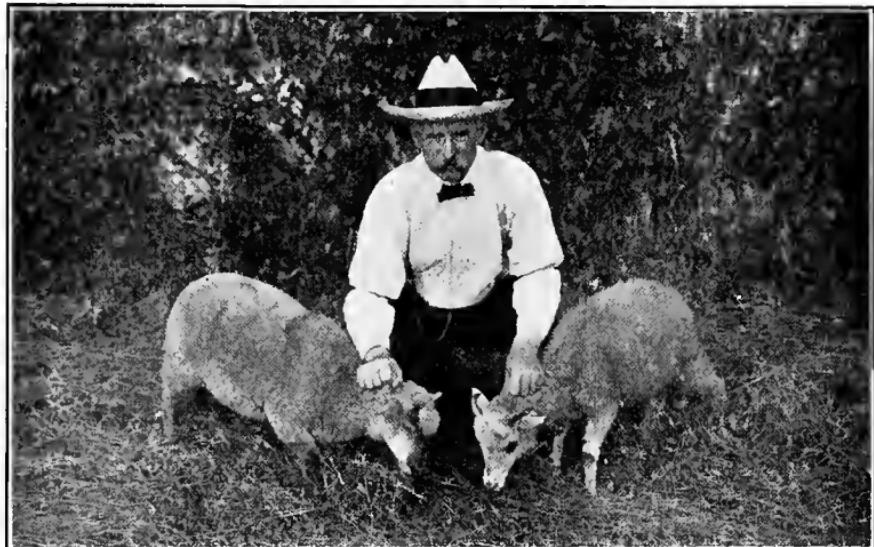
History. — There are many wild species of sheep in Asia, Africa, Europe, and on the western mountain ranges of America. The sheep was probably the first animal domesticated by man. A European species, the Merino, was brought by the Spaniards to the New World soon after its discovery. From this Spanish breed is descended most of the flocks of Mexico, New Mexico, and Texas.

Sheep are natives of mountainous countries and do best on hilly land. They never by choice seek level, open land, swampy country, nor dense forests.

Uses. — The animal is useful in many ways. Its flesh furnishes food, its fleece clothing, its skin leather, its bones fertilizers.

Sheep Raising. — Sheep are docile and easily managed, require little care and attention, and need less grain than other kinds of

live stock. Sheep feed chiefly on pasture, largely on weeds, and they improve the land on which they feed. They increase rapidly and mature early. They cost less to raise than cattle, and their flesh brings a higher price, and the fleece is clear profit. There



Courtesy of Louisiana Agricultural Station

GRADE LAMB AND SCRUB LAMB

These two lambs are the same age; they were raised together, and given the same treatment and food.

is always ready sale for lamb, mutton, and wool, and the price varies less than that of most other farm products.

Every year there are imported into the United States half a million dollars' worth of mutton and from twenty-five to thirty million dollars' worth of wool, all of which might be produced at home. American farmers would not only reap the profits which now go abroad, but their land would be improved.

No farm product makes so little demand on soil fertility as does

wool. The sale of a thousand dollars' worth of corn takes about three hundred dollars' worth of fertility from the land, the sale of

an equal value of mutton takes about fifty dollars from the land, and of wool only three or four dollars.



MERINO SHEEP—A WOOL TYPE

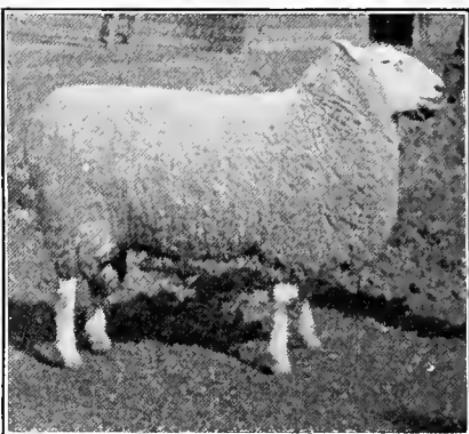
Grand champion of St. Louis World's Fair, 1904.

Merino sheep. It is a native of Spain, is hardy, well adapted to warm climates, and is the only breed which is not subject to disease when kept in large flocks. The flocks of the southwestern states are descended from them. More than half the sheep of the United States are raised in the section west of the one hundredth meridian, known as 'the Range,' where they flourish on native grasses.

Mutton Breeds.—The sheep raised in the eastern states are chiefly English mutton breeds. The most hardy and prolific of these and the most popular in the United States are

Breeds.—While all breeds furnish both wool and mutton, sheep are usually divided into wool breeds and mutton breeds, according to their chief purpose.

Wool Breed.—The best-known wool breed is the Merino.



LEICESTER SHEEP—A MUTTON TYPE

Grand champion of St. Louis World's Fair, 1904; weight, 420 lb.; fleece record, 26 lb.

what are called the 'down' breeds, the Southdown, Shropshire, Hampshire, and Oxfordshire. They have wool of medium fineness. The Southdown is more extensively raised in the United States than any other breed except the Merino. It is smaller, but hardier and more prolific than the other 'down' breeds. The Dorset is valued chiefly for the production of early lambs.

The long-wooled mutton breeds are the Leicester, Lincoln, and Cotswold.

Care of Sheep. — Where there are cheap lands, natural grasses, and open mild winters, sheep can be raised without costing their owner anything except for an occasional salting and the shearing. It is not, however, a good plan to raise any animal to see how much neglect it will bear. It should be given conditions and care to produce best results.

Sheep should be protected against dogs. They should have shelter, such as well-littered sheds on sunny slopes, protected from cold, wind, and rain. Sheep cannot bear close confinement or crowding. They need well-drained pasture; on marshy land they are subject to disease. They should have pure water, and be salted regularly. It is well to keep in a shed to which they have access a trough containing pulverized charcoal, ashes, salt, and sulphur.

By nature sheep are timid and nervous. They need quiet handling and gentle treatment. A rough, harsh, careless, or impatient master rarely reaps profit from them..

Diseases. Fly. — The diseases to which they are most subject are fly, foot rot, and scab. The first is caused by a fly, the maggots of which should be killed before they eat their way into the body. The sheep should be smeared with tar or a carbolic acid ointment.

Foot rot. — Foot rot is caused by a parasite which must be cut out; to the wound should be applied carbolic acid ointment.

Scab. — Scab is a contagious disease caused by a parasite which gets under the skin. It causes the wool to fall and not only ruins the fleece but often weakens and kills the sheep. The parasite is killed by dipping the sheep in a wash containing sulphur, tobacco, or lime and sulphur. Sheep should be dipped at least once a year to keep their skins clean and healthy.

EXERCISE

1. Do the farmers in your locality raise sheep? Do you think it would be a profitable business? Give reasons for your opinion.
2. Why do sheep especially need protection against wet weather?
3. At what season are they sheared and why?

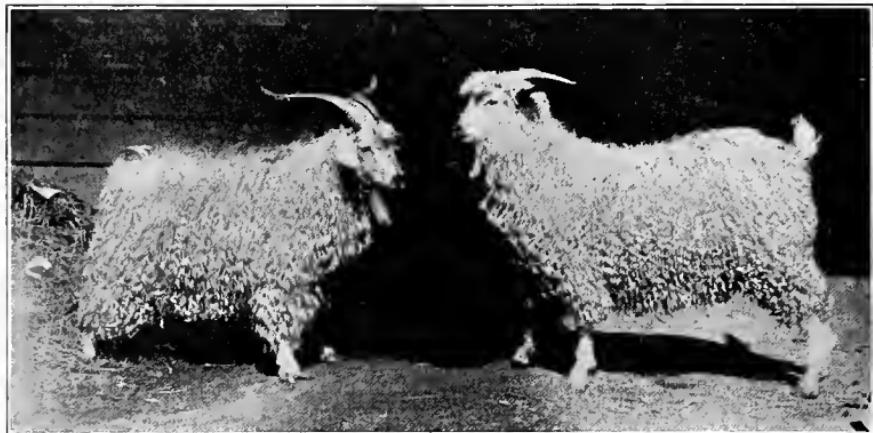
GOATS

Goat Raising. — Goat raising is a new and growing branch of stock raising in the United States. There are now about two million goats in the country. Every year about twenty million goat skins — worth about twenty-five million dollars — are imported into the United States from India, China, Russia, and other countries. The leather is used for making gloves, shoes, and other articles.

Breeds. — The Malta goats are especially prized for their milk; it is richer, more nourishing, and more wholesome than cow's milk. From goat's milk some of our best cheese is made.

The goat most favored by American farmers is the Angora. Its native place is the province of Angora in Turkey. Some peculiar property of the atmosphere there makes the coats of animals, such as cats, dogs, and goats, especially beautiful, long, soft, and silky. The fleece of the Angora goat, called mohair, is used in the manufacture of fine fabrics.

Habits. — Goats are browsers by nature, and live on weeds and brush where most other animals would starve. They pass by grass and clover to feed on thistles, briars, and thorns, which other stock will not touch. They kill weeds and brush, and give native grasses a chance to spread, fertilized by their manure.



ANGORA GOATS

Food and Care. — Except in winter, when they should be given a little sheaf oats, corn fodder, or good hay, goats find their own food. They should have salt once a week the year round. Their heavy fleece should be sheared early in spring.

Goats are hardy, easily managed, and free from disease except when confined to low, marshy places. They are as profitable as sheep and less expensive, being also free from most diseases to which sheep are subject.

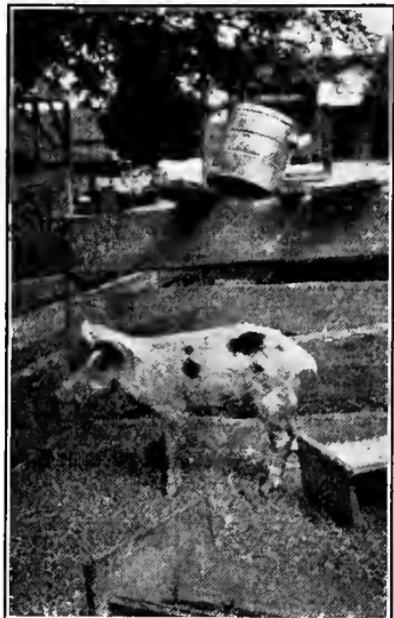
EXERCISE

Name three points in favor of goat keeping. Can you think of any objections to it?

HOGS

History.—Our domesticated hogs are descended from the wild swine native to Europe, Asia, and Africa. These wild beasts

are lean and scraggy, active and fierce. They live in swamps, jungles, and forests, and feed on vegetable and animal food. The wild hog was probably first domesticated in China. Through thousands of years of care, various breeds have been developed there which are "bladders of lard and fat." Hogs are now raised in almost every region outside the Arctic Circle.



SCRUB HOG

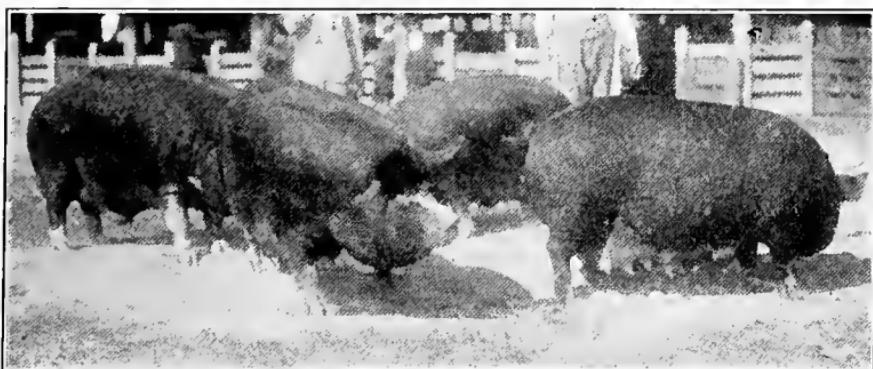
At two years old, it weighs 50 lb. Does it pay to raise such stock?

American and English Breeds.—Several breeds have been developed in the United States, which, like those of China, have much fat and little lean. The best-known American breeds are the Chester White, Poland China, and Duroc Jersey or Jersey Red.

The English improved breeds are descended from the native old English hog with foreign crosses. They are what are called bacon breeds, having longer bodies and legs and giving a larger proportion of lean meat than the Chinese and American hogs. Among the best-known English breeds are the Yorkshire, Berkshire, Tamworth, and Essex.

Hog Feeding.—In the United States hogs are raised largely in the corn belt from Ohio to Kansas. There they are called 'mortgage lifters' because farmers who became poor raising corn for market got out of debt and prospered when they fed the cheap and abundant corn to hogs and sold meat instead of grain. Corn-fed hogs are fat and lardy, and are often disposed to disease.

Hogs grow faster and are healthier when carried through the summer on green food, such as grass, clover, pea vines, and alfalfa,



BERKSHIRE HOGS

A prize-winning herd of four, weighing 2700 lb.

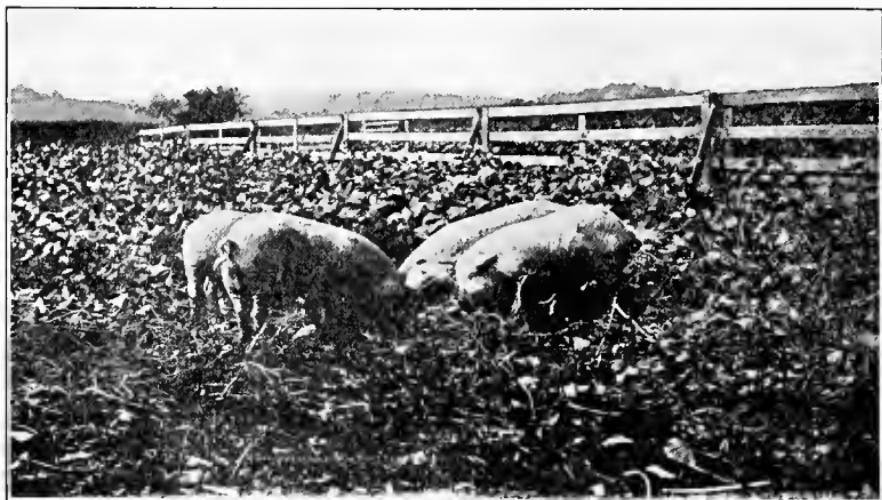
with a small ration of grain, and then are fattened largely on cereals, such as oats and corn. Recent feeding experiments show that they make larger and cheaper gains in winter when fed some bulky food, such as clover or alfalfa hay, in addition to their grain ration. For some unknown reason, cotton-seed meal, on which cattle thrive, is usually fatal to pigs, if fed any length of time.

It is often profitable to plant lots in sweet potatoes, peanuts, and other crops to be harvested by the hogs themselves.

Hogs are gross feeders, and are more prolific than any other domesticated animal, except the rabbit. Hog flesh can be more

cheaply produced than any other meat. Hogs gain a pound in weight for four or five pounds of dry food, sheep gain one for nine, and cattle one for twelve.

Disease. — Hogs are easy to keep well and are hard to cure when sick. If kept in dry, clean, well-ventilated quarters, supplied with plenty of pure water, and properly fed, they are apt to be healthy.



HOGS HURDLED ON COWPEAS

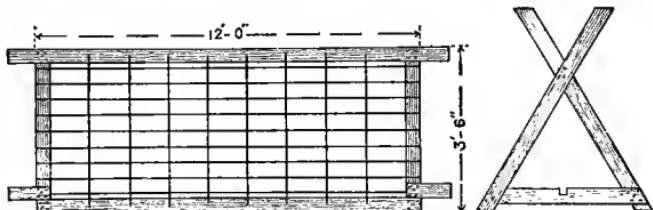
By use of hurdles, or movable fences, this field is grazed a part at a time.

The most serious and fatal disease to which they are subject is cholera. This is contagious, and the bacteria which cause it may be carried by persons, animals, and streams. A stream which has its source outside the hog lot is a constant source of danger and a frequent source of infection. Few hogs recover from cholera and the treatment must be largely preventive. A mixture of salt, sulphur, and hardwood ashes should be kept in a trough in a shed to which hogs have access. Well and sick animals should be kept

separate, and all pens should be disinfected with lime and carbolic acid washes.

Profitable Breeds. — The most profitable breeds for the farmer are those which are prolific, vigorous, and of good disposition, which mature early, and thrive on feeds easily available. Black hogs are generally preferred in the South as they are thought to bear heat better.

Earliness of maturity is one of the advantages of good breeds. It takes two years to get



A section of a hurdle, showing how it is fitted together. It is made of stout lumber and wire fencing.

a 'scrub' or common hog to the weight to which an improved breed can be brought in nine months on the same feed. It must always be remembered, however, that breeds improved by care need care to keep up their good points. They cannot shift for themselves, like the 'razor back' and the prairie ranger.

There is more profit in spring pigs pushed and killed in the fall than in those kept through the winter. It takes more food to keep and fatten hogs in cold weather. Moreover, with age and size the cost of keeping increases more rapidly than flesh. It is most profitable to sell a hog at two hundred or two hundred and fifty pounds, as each additional hundred pounds takes about twenty-four per cent more food.

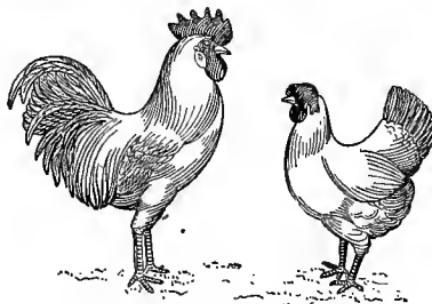
EXERCISE

1. Why is it usually profitable to keep hogs on a farm? Can you think of ways in which the business may be managed so as to make it unprofitable?

2. Name three points in favor of improved breeds; one in favor of 'scrubs.'
3. Consult the table on page 309 and make up a balanced ration for fattening hogs, using feeds that can be grown in your locality.

POULTRY

Poultry. — Poultry includes all fowls domesticated for meat, and for eggs and feathers, such as hens, turkeys, guinea fowls, peafowls, ducks, geese, and pigeons.

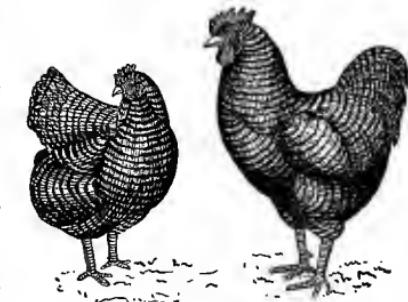


WHITE LEGHORNS—AN EGG BREED

their products is enormous. The year 1905 was worth five hundred and twenty-five million dollars; American poultry products that year were worth over five hundred million dollars.

Pure breeds are usually more profitable than common breeds which eat as much and produce less. There are two great classes, — the Mediterranean, or egg-producing breeds, and the Asiatic, or meat breeds.

Egg Breeds. — The chief egg breeds are the Leghorns, Houdans, Minorcas, and Spanish.



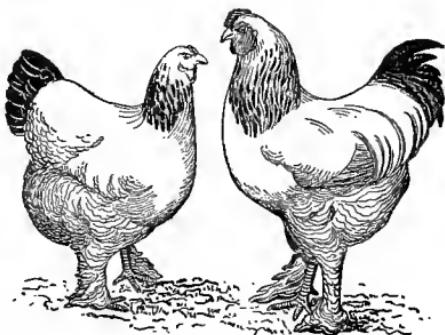
BARRED PLYMOUTH ROCKS—A GENERAL-PURPOSE BREED

Meat Breeds.—Of the large meat breeds, the most popular are the Brahmans from India, the Cochins and Langshans from China, and the Games. These are all poor or fair layers, and good sitters. The light Brahmans are the largest; a hen of that breed weighs nine and a half pounds, a cock, twelve pounds.

General-Purpose Breeds.—The Orpingtons, the Plymouth Rocks, the Wyandottes, and the Rhode Island Reds are general-purpose fowls. They are good layers, good sitters, and supply abundance of good meat. The Plymouth Rocks, Barred, White, and Buff, are the breeds most widely raised in America.

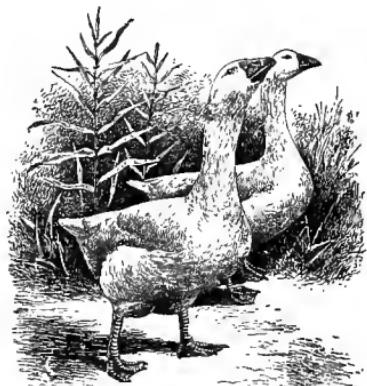
Ducks.—Ducks mature early and furnish good meat. They are freer from disease than hens and grow faster. The Pekin duck is the most popular. Ducks are as greedy eaters as hogs, and they should not be fed with other fowls. They are not good mothers; if eggs are not hatched in an incubator, it is best to hatch them under a hen and let her mother the ducklings till they are old enough to care for themselves. Contrary to the usual opinion, ducks do not need water except to drink, and can easily be raised without access to a pond or stream.

Turkeys.—Our domestic turkeys are descended from the wild ones native to America. The Bronze is the largest and most popular breed; its gobblers weigh about thirty-six pounds and its hens about twenty pounds. The White Holland is a handsome and popular breed.



WHITE BRAHMAS—A MEAT BREED

Turkeys have been so recently domesticated that they are wilder and of more roving disposition than any other barnyard fowl. They seek out-of-the-way places for nests, and thrive best when allowed free range and outdoor roosts. The meat of the turkey is especially prized, and is a favorite for Thanksgiving and Christmas dinners.



WHITE EMBDEN GEESE

Geese.—Geese are vigorous and hardy and live on food that other poultry would reject. They do not mature till they are three years old, and they often live to be twenty-five or thirty years old.

Guinea Fowls.—Guinea fowls are easily raised. They are industrious worm and bug destroyers. Their

flesh is dark, but excellent in flavor.

Peafowls.—Peafowls, formerly bred for table use, are now raised almost entirely as an ornamental breed and for their feathers.

Food.—Fowls need a balanced ration just as much as do horses and cows. The nutritive ratio for fowls is 1 : 4. They require a larger proportion of protein than most other animals. Where they have free range, they usually find seeds, grass, and insects that furnish a balanced ration to enable them to make meat and produce eggs. Fowls kept in a poultry yard must have these needs supplied.

Many good poultry-raisers feed their adult fowls three times a day, giving grain for breakfast, green food, such as clover and lettuce, for dinner, and mash containing meal or meat scraps for supper.

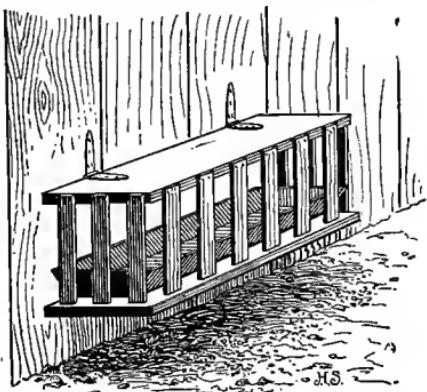
Starchy foods, such as sweet potatoes, are beneficial in small quantities; when they are fed too freely, fowls fatten and stop laying. Corn, also, is a fattening food which should be sparingly used. Wheat is good for fowls, and oats is better still. It is well to scatter grain in straw or litter so that the fowls are compelled to scratch for it. The more exercise they take the more eggs they lay. "If you wish hens to pay their board, make them work for it." They should be fed, but not overfed, a variety of wholesome food. To produce eggs in winter, fowls must have green food and warm houses.

Fowls should always be supplied with gritty substances, such as coarse sand or crushed oyster shells. These aid digestion and furnish material for bones and eggshells.

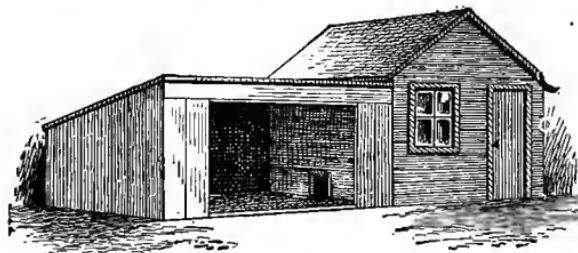
Water. — Fowls should always be provided with pure water. It should be arranged so that they have free access to it but cannot foul it. For this purpose it is well to use a long pan with a cover of slats two inches apart.

A SMALL HENHOUSE, WITH SCRATCHING-SHED ATTACHED

Quarters. — To keep poultry healthy, they must have clean, well-drained quarters. The nests should be arranged so as to be easily moved and



A GOOD DRINKING-TROUGH FOR FOWLS



cleaned. Perches, also, should be movable; they should be low, not more than two and a half or three feet from the ground if large breeds are raised.



EGG PRODUCT OF A ONE-YEAR-OLD HEN

Fowls should be protected against them by insect powder dusted under their feathers, and by having access to dust boxes filled with dust or fine, loose earth. Mites are blood-sucking parasites that live in the house and attack the fowls at night. They can be destroyed by spraying and washing the inside of the house, the nests, and perches, often and thoroughly, with kerosene, kerosene emulsion, or whitewash containing carbolic acid.

In cold sections especially, there should be a scratching-shed attached to the house. It should open to the south so as to give sunshine, and the floor should be covered with straw.

The house and shed should be kept free from lice and mites. Lice live on fowls.



EGG PRODUCT OF A TWO-YEAR-OLD HEN

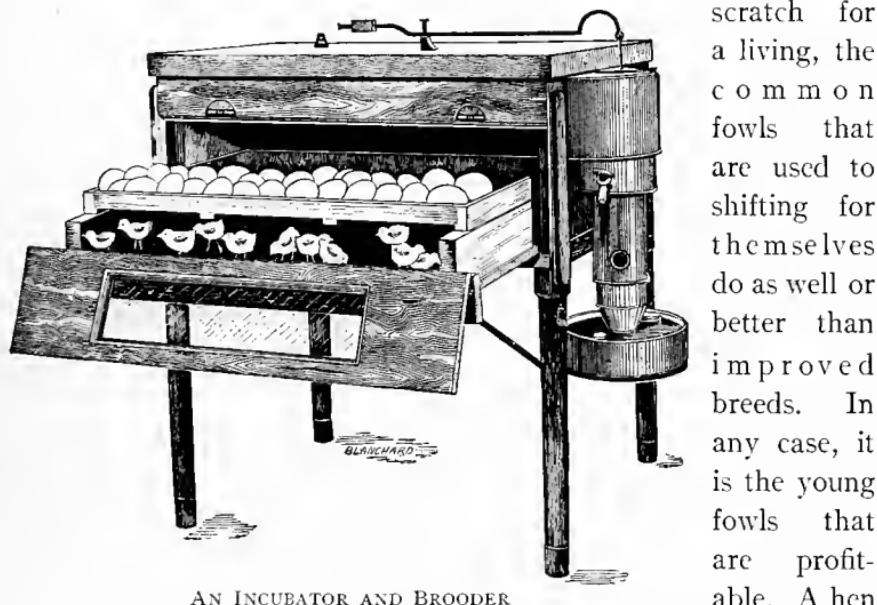
Diseases. — Filth and dampness are directly or indirectly the cause of most poultry diseases. Cholera, the most fatal and con-

tagious of these diseases, is often the result of bad food, impure water, or overcrowding in a dirty house. It is caused by bacteria which are taken in through the mouth. Feeding and watering places should be disinfected and kept clean. Sick fowls should be killed and burned or buried deep.

Care. — It must always be remembered that good breeds are not enough. Good food and good care are needed. Improved breeds given proper care yield the largest profits in meat and eggs. But when they are neglected and left to



EGG PRODUCT OF A THREE-YEAR-OLD HEN



AN INCUBATOR AND BROODER

three years old is usually past her usefulness as an egg producer.

scratch for a living, the common fowls that are used to shifting for themselves do as well or better than improved breeds. In any case, it is the young fowls that are profitable. A hen

Incubators and Brooders. — When fowls are raised on a large scale, it is convenient and economical to use incubators and brooders. In the incubators the eggs are hatched by artificial heat, and the brooders furnish homes for the little chickens. The brooders must be kept at the proper temperature, and the chickens must be fed often and little at a time. Raising chickens requires constant attention to details which is gained by experience.

EXERCISE

Would you not like to raise some fowls? They require little room, but should have proper care. You can begin with one hen. If she is kept alone, her eggs will be infertile and will not hatch. What will you feed her in summer? What food and care will you give her in winter so as to keep her laying?

BEES

Breeds. — There is as much difference in breeds of bees as in breeds of cattle or sheep. A colony of the common East India bees produces about ten or twelve pounds of honey a season; a single colony of Cyprian bees has been known to produce a thousand pounds.

Colonies, or swarms, of our native brown or black bees make their homes in hollow trees. These bees are often kept on farms; they are spiteful, less able to protect themselves against insect enemies than some other breeds, and produce less honey. Cyprian bees are industrious but cross. The Italians are good workers and less spiteful. The Corniolans are gentle, hardy, and industrious. The Caucasians, a breed recently introduced into this country by the Department of Agriculture, bid fair to become popular. They are gentle and are excellent honey-gatherers.

Beekeeping. — Beekeeping is most profitable in localities where blossoms are abundant. Buckwheat, asters, and mints,

clovers, alfalfa, and other legumes, the linden, tulip, or poplar, and fruit trees are favorites with bees. Fruit trees should not be sprayed in blossom time for fear of poisoning the insect visitors. Even when a fruit grower is not a beekeeper, he should protect bees on account of their service as pollen carriers.

There are many successful beekeepers in large cities. Their colonies find abundant food in the flowers, shrubs, and trees of gardens, parks, and streets. Beekeeping is light and profitable work, and pleasant also when one is freed from the fear and danger of stings. If bees are dealt with gently and smoked properly, they are easily managed.

Bee Colony. — The life of a bee family, or colony, is very interesting. In spring there are three kinds of bees in each colony. There is one queen, several hundred drones, and about thirty-five or forty thousand workers.

Queen. — The queen bee lays all the eggs — sometimes as many as four thousand in twenty-four hours — and leads the colony when it swarms.

Drones. — The drones, or males, gather no honey and have no sting.

Workers. — The worker bee is the smallest, but on it falls all the labor of making comb, beebread, and honey, and of caring for the larvæ, or undeveloped bees. It has a sting to protect itself and to attack its enemies. In the fall the workers drive



Queen



Drone



Worker

CORNOLAN BEES

out the drones, leaving them to starve or stinging them to death if they try to return.

It takes about twenty-one days for eggs to become perfect bees. Young workers begin life as nurses for the larvæ. When about ten days old, they try their wings; in a few days they are busy with field work, making honey.

Swarms.—As soon as the oldest queen's cell is sealed, the old queen leaves the hive, followed by many bees. This is called a swarm. It gathers in a mass about the queen on a branch of a tree or elsewhere. The beekeeper cuts off this branch or shakes the bees into a basket or on a cloth and puts them into an empty hive.

Hives.—Good hives with movable frames should be used, so that filled combs may be taken out at will. In order to let the bees devote their time to honey making, artificial combs are sometimes used, or natural combs have the honey removed in a machine called a honey extractor and are put back to be refilled. A tin-lined entrance to the hive protects the bees against their enemies, mice. An anti-robbing entrance guards against robber bees which are apt to steal honey from weak hives.

Winter Care.—The beekeeper should be careful not to deprive his colony of winter food. When the honey is taken in late fall, a thick sirup made of sugar should be put where the bees have access to it. They soon store this up for winter food. In severe climates the hives should be kept through the winter in a dry, well-ventilated, moderately warm place, such as a good cellar.

EXERCISE

1. What flowers have you seen visited by bees? At what season do bees make most honey and why?
2. Have you ever seen a queen bee? Can you distinguish a drone from a worker?

OUTLINE OF CHAPTER SEVEN

MISCELLANEOUS

Trees:

Uses of trees:

Productive:

 Wood for fuel

 Timber for building

 Pulp for paper

 Yield fruit, nuts, spices

 Supply sugar, tar, pitch, turpentine, gums

Protective:

 Regulate water supply

 Temper climate

 Serve as wind breaks

Forest enemies:

 Fungi, insects, wind, grazing and browsing animals, fire, man

 Forestry and destructive lumbering

 Tree planting

Farm Tools:

Advantages:

 Save labor

 Save time

 Do work better

Requirements:

 Proper use and adjustment

 Repair and care

Good Roads:

Advantages:

 Lessen cost of hauling

 Increase ease of intercourse

Requirements:

Proper grade

Good drainage

Well-prepared surface:

Steel, stone, gravel, earth

Care and repair

The Help of Science:

General

United States Department of Agriculture

State Agricultural Experiment Stations

School Gardens:

Suggestions

School grounds

Landscape gardening

CHAPTER SEVEN

MISCELLANEOUS

TREES

Tree in Winter. — What a beautiful, wonderful, useful thing is a tree! Look at one as it stands outlined against the winter sky. How substantial are its trunk and branches! It is hard to realize that this solid body is built up from the invisible air, yet so it is. Only one part in one hundred of dry wood is derived from the soil; the other ninety-nine parts are derived from the air. Half of the substance is carbon; the remainder is chiefly oxygen and hydrogen with a little nitrogen.

Tree in Summer. — Consider the tree in summer. There are hundreds and thousands of leaves, busy in a factory very unlike the noisy ones of man. What a wonderful amount of work they do! Growing, they prepare food for the tree, and make a shade grateful to man and beast; fallen, they serve as a blanket to keep the earth warm and moist, and form mold and humus to enrich the soil.

With all his sciences, man cannot understand exactly the processes of their work nor the power by which sap mounts to the topmost leaf on the tree fifty or a hundred or three hundred feet from the ground.



A SYCAMORE TREE IN SUMMER
AND IN WINTER

Tree Products. — Orchard and nut-bearing trees are valued for their fruits. The sap of some trees furnishes useful products — the maple yields sugar; the pine supplies tar, pitch, and turpentine; the camphor produces gum. Millions of trees are cut every year to supply pulp for paper making. Tens and hundreds of millions are cut to furnish wood for fuel and timber for building purposes, from a matchbox to a house.

Lumbering. — Lumbering, or cutting trees for market, ranks fourth among the great industries of the United States. It occupies many men in the eastern states and along the Gulf Coast. It is the chief industry in the Northwest, in the states of Washington, Oregon, Idaho, and Montana, where there are original forests of fir, spruce, hemlock, and cedar. From sunrise to sunset the year round, ax and saw are busy, harvesting the great crop which it has taken centuries to grow.

Indirect Benefits of Trees. — Suppose we could do without the

product of trees — fruits, nuts, resins, gums, material for fuel and building. We might use iron and steel for fences and ships; cement and stone for building purposes; coal, oil, gas, and electricity for fuel. Still we should be unable to do without trees. Their indirect benefits are greater than their direct ones. Forests, which are trees in masses, regu-

late the water supply, temper the extremes of heat and cold, and break the force of wind and storm.

Effect on Water Supply. — You have learned how important to agriculture is the supply of water. Now let us see how this is



AN OAK TREE, GROWING IN THE OPEN

affected by trees. Examine some wood mold, as we call the soil of the forest. It is loose and damp, made up of decayed and decaying leaves and twigs. The wood mold and tree roots form a vast sponge to catch and hold the rainfall. They give it out gradually and regularly by capillarity and evaporation and through streams. They protect the land against surface washing and, to a great extent, against loss of water by evaporation.

With the wood mold compare the hard compact earth on a barren hillside. Instead of sinking in this, much water runs off, leaving it hard and dry. It is subject to floods and to droughts which affect the forest but little.

If you consult a map of the United States, you find that the head waters of its great rivers are in the mountains. Nature has covered the mountain sides with forests, which store up floods and supply the waters gradually to the streams. What will happen if these forests be cut? The mountains will be changed from reservoirs to mere watersheds. Down their steep slopes floods will rush to the valleys and plains below, destroying and bearing away crops, plantations, villages.

More than one third of the seaward-going water of the United States makes its way through the Mississippi. How important it is to have forest reservoirs on its head waters, and to use and distribute the water along its course as evenly as possible! If this be not done, the fertile valley will finally be destroyed. It has been neglected so far, and every year the levees are piled higher, every year the flood-mark rises.

It is necessary to preserve forests not only to regulate the flow of streams, but to give a regular supply of water for irrigation. Irrigation is needed in nearly one third of the United States. Without forests, it is impossible.

National Forests.—Since 1891 the United States government

has set apart sixty-one forest reservations, containing over sixty-one million acres, at the head waters of streams and on high land in the West.

Forest Enemies. — What are the chief enemies of the forest which is so useful, so necessary to man? They are fungi, wind, insects, grazing and browsing animals, fire, and man himself.



FUNGI ON AN OAK TREE

Fungi. — Like other plants of the higher orders, trees have fungous pests that cause decay and death.

Wind. — Windstorms often uproot trees and in certain sections injure and destroy miles of forests.

Insects. — Insects frequently kill trees and even whole forests. Some, such as ants and borers, burrow into the wood until it is honeycombed. Others, such as the larvae of sawflies and moths, kill the trees by destroying the foliage.

Grazing. — Wild and domestic animals do harm in various ways. Pasturing in moderation is not harmful; but large herds and flocks injure forest soil by trampling and close grazing, and they bruise and break young trees. Sheep and goats which browse on the foliage are most injurious.

Fire. — Next to man, the great enemy of the forest is fire. It often sweeps over miles of land, killing young trees and injuring old ones. In the decaying wood, worms finish the work of destruction begun by fire. Even the soil is destroyed by being deprived of humus.

Man. — Man, directly or indirectly, is the most destructive of all the enemies of the forest. He fells trees in vast quantities, and by carelessness and bad methods he increases the harm done. He

starts forest fires; he cuts wood so as to expose the forest to the damage of wind, insects, and fungi; he inflicts injury by overgrazing, especially with sheep and goats. Too often he treats his friend, the forest, as if it were a deadly enemy that he is bent on destroying. This attitude is the natural result of the early state



FOREST LAND IN MINNESOTA LAID WASTE BY LUMBERING AND FIRE

of affairs in this country. When settlers first came to the New World, it was necessary to make clearings and cut forests. Thus it came about that, "In the old pioneer days the American had but one thought about a tree and that was to cut it down."

But conditions have changed. For the sake of farming and other interests, we need to preserve forests. This does not mean that trees should never be cut. As other crops should be harvested,

so should that of the woods. The old trees should be cut so as to spare and benefit the young ones and thus renew the forest. It is truly said that a forest is more than a storehouse of wood; it is a factory for wood and a reservoir for water.

Destructive Lumbering. — Suppose a lumberman who feels no interest in forest preservation has a hundred thousand acres of land in original forest, containing six hundred million feet of lumber. He puts in a big plant so as to cut a hundred million feet a year. He cuts everything large enough to saw, and injures and destroys the young growth. Fungi, insects, and fire are given opportunity for their deadly work. At the end of six years the lumberman has the money for his six hundred million feet of lumber, but he has destroyed the forest.

Forestry. — Suppose a similar tract of land comes into the possession of a forester, a man who wishes to sell lumber and also to preserve the forest. He puts in a smaller plant, cuts the mature trees, and leaves the thrifty young ones to develop. At the end of six years he has taken in less money than the lumberman, but he has property which is paying profits and increasing in value. With the old trees out of the way, the young ones have more room, air, sunshine, and plant food, and so grow faster.

Do not the two instances remind you of the old story of the man with the goose that laid golden eggs? The wasteful lumberman kills his goose, the forester keeps his to lay golden eggs.

The economical care of woodland is the duty not only of the men who control vast areas, but also of the farmer. It is important for him to take care of his wood lot, though it be only a few acres. By cutting old trees and sparing growing ones, he can preserve and increase its usefulness. Rough land and hillsides are more valuable in forest than for farming purposes. It is often profitable to plant trees on such land.

Tree Planting.—The planting of trees is most important on prairie land, where they are needed for wind breaks and for wood



VIRGIN STAND OF SOUTHERN YELLOW PINE

and fuel. These vast, treeless plains roll their sea of verdure from the Missouri River westward to the foothills of the Rocky Mountains.

In the prairie state of Nebraska, Arbor Day was originated in 1872 by Mr. Morton, who afterward became Secretary of Agriculture. Arbor Day, set apart for the planting of trees, is now observed in nearly every state of the Union and in many countries of Europe.

It is important to plant trees properly and to give them proper care. Their culture is simple, consisting of keeping the soil mellow and free from weeds for three or four years till they so shade the ground as to make this unnecessary. Animals should not be permitted to bruise the young trees nor to browse on the tender shoots.

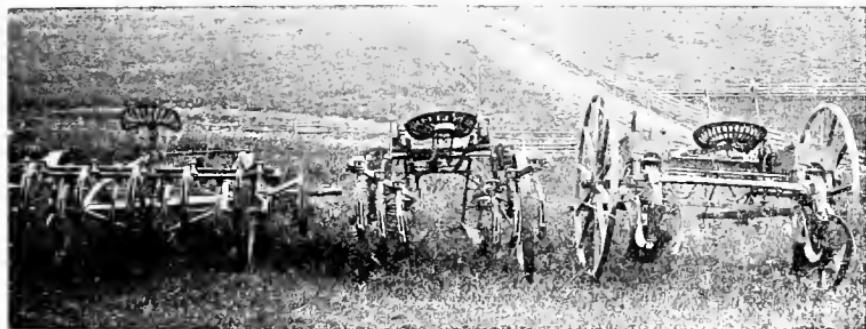
The kinds of trees to be planted depend on locality and conditions; like other plants, trees have certain requirements as to moisture and climate. The European larch thrives on rough rocky soils and on wet undrained ones. It is hardy and of rapid growth, and its timber is durable. The catalpa is a beautiful tree that bears large clusters of fragrant white blossoms. It grows rapidly and its durable wood is valuable especially for fence posts and railroad ties.

EXERCISE

1. Make a list of the orchard and the nut-bearing trees of your section. Name ten useful tree products.
2. Get a specimen of wood mold and one of soil from a barren hillside. Compare the two.
3. Do you not know some spot that would be improved by having a tree grow there? Select a sapling of the kind that you think likely to thrive in that location and set it out. Remember that it is better to have one tree well set and cared for than a dozen carelessly set and neglected. Follow carefully the rules for transplanting on pages 63 and 172.
4. Does your school observe Arbor Day? If it has not done so in the past, it will be well to begin this year.

FARM TOOLS

Use of Tools. — Agriculture, you know, cannot be carried on without tools. The poorest farmer has his hoe and plow and grain blade. On the best farms there is an array of tools — plows and harrows to prepare soil; planters, drills, and transplanters to put in crops; cultivators, horse hoes, and weeders to till them; diggers, mowers, reapers, harvesters, huskers, shredders, threshers to harvest



IMPLEMENT USED IN PRODUCING THE CROP OF CORN ILLUSTRATED ON PAGE 142

products and prepare them for use. Many of these are recent inventions; most of them have been made or perfected by Americans.

The Plow. — The first agricultural tools were few in number and simple in form. Consider, for instance, the plow which is the oldest of all. It was made first of the crooked branch of a tree, pointed and hardened by fire. This was drawn by hand. Then it was adapted to draft animals, such as oxen and horses. By degrees it took its present shape, but it was still made of wood. Then the wooden parts were protected by wrought iron.

About the end of the eighteenth century, a cast-iron plow-share, or point, was invented. At first American farmers would



WORKING A CROP WITH HAND HOES



HORSE HOE, OR HOEING MACHINE

This machine does as much work as several hand hoes, and does it better.

not use it. Seeing that weeds as well as crop plants responded to the better cultivation, they said that it poisoned the land and made weeds grow. Gradually, however, it came into use, only to give way in turn to the share made of chilled steel. Now there are steel gang plows that cut ten or more furrows at a time. Run by



CORN PLANTER

This implement drills fertilizer and drops and covers the grain. Formerly three men were required to do this work.

steam or electric power, they do the work of ten men and thirty or forty horses.

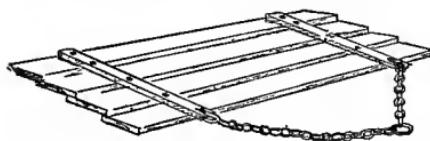
Profits from Use of Good Tools. — Buying good tools suitable for the cultivation of his crops is one of the best investments a farmer can make. They save labor and time and do the work better than it could otherwise be done.

Tools save Labor. — Good tools save labor by enabling one man or one team to do the work of two or more. It would take several men to stir as much soil and destroy as many weeds in one day as does the horse hoe or cultivator, or to cut as much hay or grain as

does the mower or reaper. The cost of wages and board for extra farm hands is thus saved. Thousands of dollars are paid in wages every year for work that could be done with less expense and trouble by the use of machinery. Moreover, the farmer who has his laborer in the shed is sure of getting it in the field when it is needed. This is not always the case when he has to depend on hiring workmen.

Tools save Time. — Good tools do work more rapidly than it can be done by hand. Thus they save time, and nowhere is it

truer than on the farm that time is money. Work done at the right time is the work that pays. The soil needs to be stirred when it is in proper condition; in a few days or hours, it may be too wet



A USEFUL HARROW MADE OF HEAVY PLANK

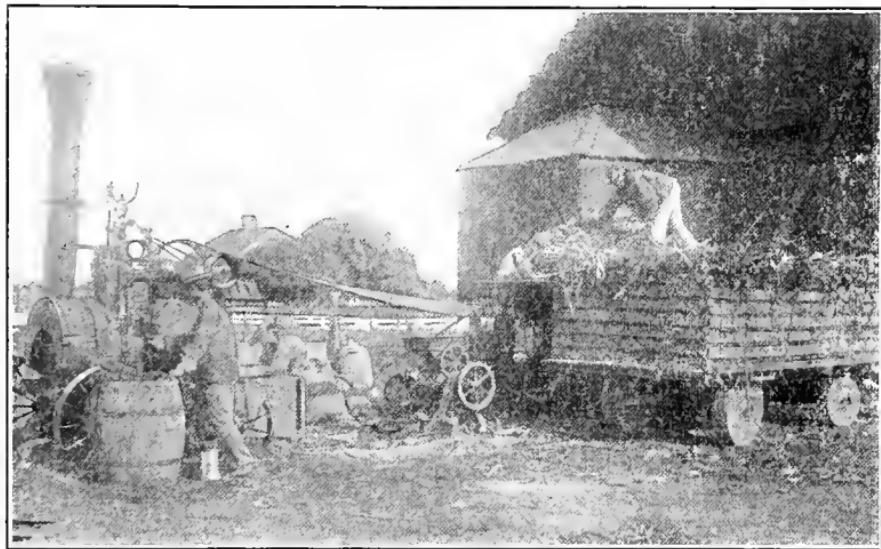
or too dry. Crops need to be cultivated and harvested and housed at the right time; if this be not done, they may be injured or lost.

With the tools in use in 1830 it took a man ten hours and twenty-five minutes to plow, harrow, and sow with wheat one acre of land; with the combined steam gang-plow, harrow, and seeder now in use, it takes forty-five minutes to do the same work. In 1830 to reap that acre of wheat with the cradle and thresh it with the flail took a man twenty-three hours and twenty minutes; with the steam harvester seven men can in nine minutes cut and thresh the same amount of grain and put it in bags ready for the mill.

Tools save Money. — By saving labor and time, improved tools reduce the cost of producing a crop. The farmers of the West have taken advantage of this fact. With little labor and at the least possible cost, they raise large crops of grain. Their level land, free from stumps and stones, is well adapted to the use of ma-

chinery. On rocky, hilly land machinery cannot be used to so great advantage.

Tools do Good Work.—Improved tools often do work better than it was done by old methods. Modern plows and harrows break the soil deeper and fine it better than the old wooden plows.



Courtesy of Louisiana Agricultural Station

SHREDDING CORN

This machine takes the ears from the stalks, husks the ears, and shreds the stalks, blades, and husks

The grain drill sows seed more evenly than it can be distributed by hand. The steam thresher separates grain from the straw and chaff better than does the old-fashioned flail. A cutting or shredding machine is needed to make cornstalks into good fodder.

Weight of Machinery.—Much of the improved machinery is heavy and requires large strong horses and mules or steam power to work it. A machine, like a man, needs weight and strength in order to do a great deal of work.

Tools to Use. — Every farmer should know and use the tools which give the best results for his land and his crops. The shape of a plow, for instance, should be adapted to the soil and to the purpose for which it is to be used. Every plow should, as farmers say, 'swim free,' requiring little pressure on the handles to guide it. It should 'enter the ground easily, run steadily, and clean itself well.'

Care of Tools. — Good tools, as has been said, are a good investment for the farmer. But he loses the profit on his investment if by misuse or neglect he changes good tools into bad ones. Every year farm machinery worth millions of dollars is injured and lost by lack of care. Tools should be kept clean and well oiled, the burs tight, with all parts properly adjusted. A machine is no stronger than its weakest part. Its usefulness ends when this is broken by careless use, or worn out by friction caused by improper adjustment, dirt, and lack of oil. Replacement of old parts by new ones is expensive. A good machine may have its life so shortened by misuse and neglect as to be a source of loss instead of profit to its owner.

Tools should be protected against exposure to weather. The rust of metal and the weathering of woodwork during a winter's exposure injures tools more than does a season's use. When plows and other tools are laid by, even for a few weeks, they should be cleaned, wiped dry, and protected against rust. Needed repairs should then be made so as to have them ready for use next time.

On every farm there is needed a shed or house for tools. This should be so arranged that heavy machinery can be driven in at one door and out at another.

Outbuildings. — Outbuildings should be arranged as conveniently as possible, at the back of the house. They should be connected with the house by walks of gravel, cinders, sand, plank, or cement. The stable should not be on the windward side of the

house. The outbuildings should not be arranged so that it is necessary to go through the stable yard in order to reach the stable, crib, or silo. The silo should be near the barn, and should be strong and air-tight and smooth inside.

EXERCISE

1. Name and describe three necessary farm tools. Describe one improved tool and tell the advantages of its use.
2. Suppose a farmer buys a corn planter for sixteen dollars that saves him every year three dollars and a half in labor. How long must it last to repay cost? If repairs every year cost ninety cents, how much longer must it last to repay cost?
3. Examine and compare the tools used by different farmers of your neighborhood. Compare cost and work, and estimate their value to the farmer.

GOOD ROADS

Disadvantages of Bad Roads. — Roads are of importance to many people, but most of all to those who live on farms and have to haul all their produce over them and pass over them for all communication with the outside world. Bad roads interfere with both the social and the business life of the farm. They increase greatly the labor and expense of marketing a crop. In many cases they render it impossible to market perishable crops, such as melons, fruits, and vegetables. It is so disagreeable to travel on bad roads, that they lessen church and school attendance and neighborly visiting.

As soon as farmers want good roads enough to insist upon having them, every bad road in our country will be replaced by a good one. The millions of dollars which are now wasted every year on bad roads will be used to maintain good ones. Instead of

having the worst roads of any civilized country in the world, the United States will have the best.

What makes Roads Bad.—What makes a road bad? If you ride a bicycle, you have learned some things from experience. You know how tiresome it is to climb hills; you go far out of the way to



THE CONDITION OF THIS ROAD IS DUE TO LACK OF PROPER GRADING AND DRAINAGE

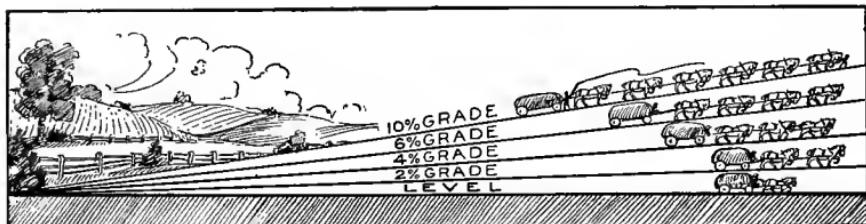
avoid one that is long and steep. It is unpleasant to ride on a road rough with stones, roots, ruts, and mudholes. It is more difficult to travel on a soft yielding surface than on a hard firm one. These things, which make a road bad for you, make it bad for a horse and determine how heavy a load he can pull.

Let us consider these points separately.

Grade.—The grade, or ascent, is a matter of prime importance. This requires more careful consideration in laying out a

road than any other point, and yet it is often left to chance. A footpath up hills and across swamps becomes a bridle path, then a neighborhood road, then a public highway. Often it is impossible to make a good road along such a route. Money and labor spent on it are wasted. A public road, especially in a hilly country, should be laid out by a good road engineer. It should go around hills or along their sides instead of across them.

It is much more important to have grades gradual than roads straight. Increased ease of travel more than makes up for in-



SKETCH SHOWING THE NUMBER OF HORSES REQUIRED TO HAUL THE SAME LOAD OVER DIFFERENT GRADES

creased distance. A horse that can pull two thousand pounds on a level road can pull only four fifths as much, or sixteen hundred pounds, when the grade is two feet to the hundred; when the grade is ten feet to the hundred he can pull only five hundred pounds, or one fourth as much as on a level road. A public road should, of course, be as straight as good grading will allow, but the grade should not be more than three feet in a hundred.

For practical purposes, a road is no better than its worst part. Take, for instance, the case of a road almost level except for one hill that has a ten per cent grade. A farmer who has to haul produce along the road can put on his team no heavier load than it can pull up that hill. He would gladly travel a longer road that

avoids the steep grade and enables him to carry his produce at one load instead of two.

Drainage. — Drainage is another important point. Water is the great road destroyer. It makes mudholes on level land, gullies on hills, and ruts everywhere. The only way to protect a road against injury from surplus water is to have on each side ditches below the level of the roadbed.

The roadbed should be highest in the middle and slope to each side, having a fall of one inch to each two or three or four feet. Surface ditches should never cross the road; there should be



CROSS SECTION OF A GOOD ROAD AND A BAD ROAD

The good road slopes to the sides; the bad one, indicated by dotted line, slopes to the middle.

underdrains for this purpose. There should be underdrains in low wet places also. These should be either tile drains or ditches filled with stones and brush as described on page 88.

Surface. — Another matter of importance is the road surface. A hard smooth surface is best. On a steel road one horse can pull as much as twenty on a common dirt road. The best roadbed is steel; next to that is stone. A good durable road is made by putting a layer of hard, broken stone on a good foundation, then a layer of smaller stones, crushed and rolled so as to obtain a hard, smooth surface. The first cost of steel or stone roads is large, but they are so durable and require so few repairs that they are cheap in the long run. On an old road in New Jersey twenty-five baskets of produce was considered a load; the dirt road was replaced by a well-graded stone one, and on this a hundred or a hundred and twenty-five baskets of produce are carried at a load.

Well-packed gravel on a good foundation makes a good road. Ordinary earth roads can be greatly improved by proper grading and drainage, and by frequent rolling and dragging, so as to keep the surface smooth and hard. The system practiced by



A GOOD ROAD

A year ago two horses could haul only two bales of cotton over this road; after improvement, the same horses haul twelve bales.

Mr. King, of Missouri, has been adopted by thousands of farmers throughout the country and has improved thousands of miles of roads. The road is dragged after each rain or thaw with a split-log drag so hitched that the earth is drawn toward the center of the road. This drag is drawn down one side of the road and

back the other. It distributes the moist earth evenly and prepares a smooth hard surface from which rain runs off.

Care of Roads. — No matter how well built a road is, it becomes bad if it is not given proper care. Drains should be kept open; depressions should be filled with the material of the roadbed before they become mudholes. It is easier and less costly to keep a road good than to repair a bad one.

EXERCISE

Compare the best road or street with the worst one that you know. What are the chief points of difference? How could the bad one be improved?

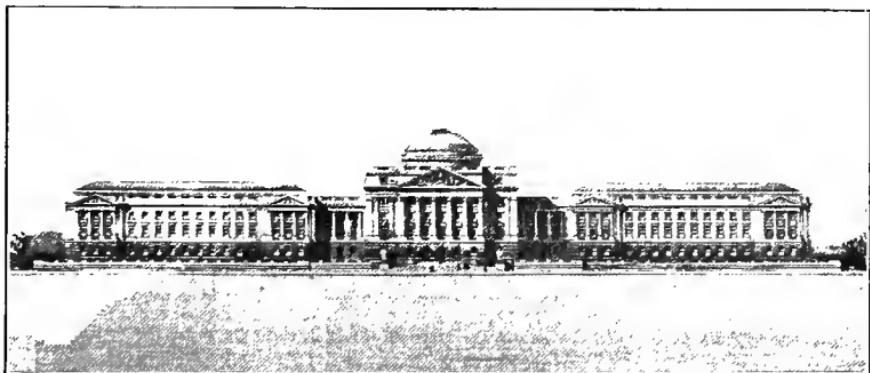
THE HELP OF SCIENCE

Work of Farmers. — Year after year, century after century, farmers learned facts by observation and developed methods by experiments. These facts and methods were handed down from father to son and grandson. They were accepted and practiced with little knowledge of the underlying principles.

Studies of Scientists. — Instead of investigating and explaining these principles, students devoted themselves chiefly to pure science. Chemists, for instance, gave farmers little more aid than did astronomers. The last sixty years, however, has witnessed a great change. Scientists have turned their attention more and more to practical subjects. Chemists have analyzed soils, learned what elements plants need for food and in what forms these must be supplied; they have found out which of these available elements are sometimes lacking, and how they may be supplied by chemicals. The result of these investigations is the production and use of millions of dollars' worth of fertilizers and a vast increase in the productive power of land.

As you learned in connection with stock feeding, scientists have studied animal foods and food values. The application of the principles discovered by them has made stock feeding less costly and more profitable.

United States Department of Agriculture.—Our government, through the work of practical scientists in the Department of Agriculture, does much to develop the great industry which every year produces over half of the wealth of the country. The benefits of



THE NEW BUILDING OF THE DEPARTMENT OF AGRICULTURE

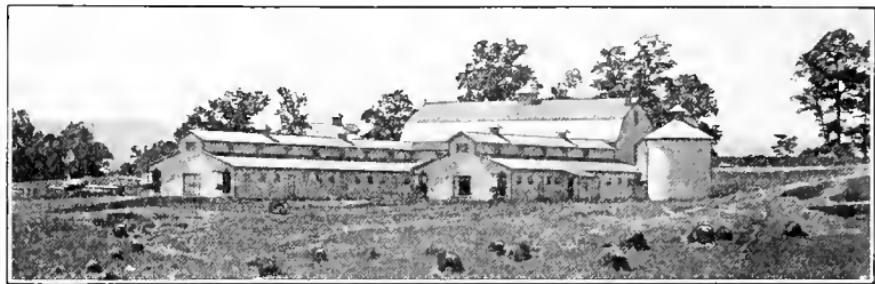
the Department of Agriculture extend over all the country. The Department is divided into parts, called Bureaus, each having a special line of work.

State Experiment Stations.—There is in each state an Agricultural Experiment Station supported by government and state funds. These stations carry on scientific agriculture along lines adapted to the special industries and conditions of the states. The work of the Illinois Station in corn breeding has been worth millions of dollars to farmers in corn-growing sections. The Tennessee Station, through careful selection, has developed strains of wheat and barley that make good crops in the South where other varieties do not thrive. The North Dakota Station originated the

use of formalin to destroy smut on grain—making an annual saving in that state alone of three million dollars. Every station is doing interesting and helpful work for the farmers.

Department and State Publications.—The results of the work of the Department of Agriculture and of State Stations are published in pamphlets, called bulletins.

The Year Book published annually by the Department of Agriculture is sent free on request. Direct your application to the con-



BARN AND SILO AT THE VIRGINIA AGRICULTURAL EXPERIMENT STATION

gressman of your district or to either of the United States senators of your state.

The Farmers' Bulletins published by the Department of Agriculture are sent free on request. Direct your application to your congressman or to one of your senators or to the Secretary of Agriculture, Washington, D.C.

The Bulletins of the State Experiment Stations are sent free on request to any person in the state. Write to the Director of the Agricultural Experiment Station of your state for the bulletins you wish, or ask to have your name put on the permanent mailing list to receive all its bulletins.

On request to the directors, valuable bulletins can often be obtained from other State Stations at little or no cost.

A list of State Experiment Stations is given on page 312.

SCHOOL GARDENS

School Gardens.—There are over a hundred thousand school gardens in Europe, and thousands have been established in the United States within the last few years. In the grounds of the Department of Agriculture in Washington city there is a model garden. In a general garden are raised our agricultural staples,—tobacco, cereals, grasses, and fiber plants, such as cotton and flax. In his or her individual plot each pupil raises vegetables and flowers. Work in these gardens trains habits of observation and gives practical knowledge of our garden, orchard, and field crops and their care.

Size and Arrangement.—The size of a school garden, and whether there are general or individual beds, depend upon the grounds available for the purpose. There should be plots, if only large enough to contain a few plants, for the staple crops of the section and for common vegetables and flowers. A large garden should be plowed; a small one should be spaded. Walks should be laid off between the beds. It is well to have the rows run north and south, as the plants thus get more sunshine. Tall-growing plants should be put on the north side.

Suggestions.—For vegetables choose common, easily-grown ones, such as lettuce, radishes, onions, tomatoes, beans, beets, and corn.

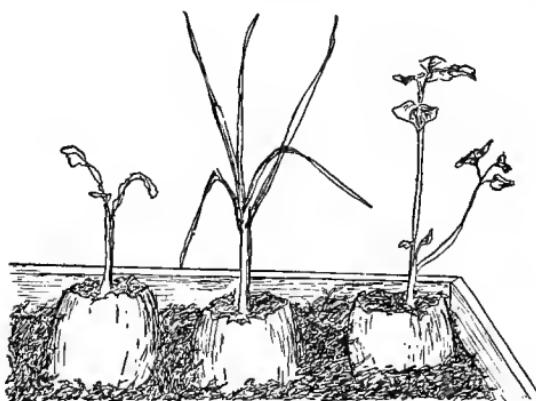


A YOUNG GARDENER

For flowers select hardy ones, such as phlox, pansies, verbenas, and California poppies. Test seeds for purity and vitality, and plant them in soil made firm and mellow. Do not crowd the rows or plants. Cultivate the garden well and keep it free from weeds. Keep the walks smooth and clean. If possible, continue the work in vacation and have an exhibition of the best fruits and vegetables.

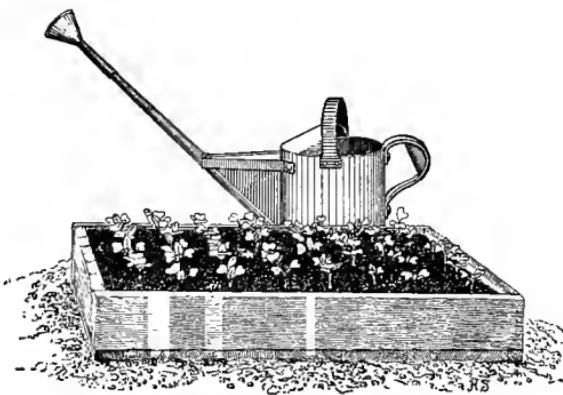
Plants for transplanting may be raised from slips set in a box of sand, kept damp. Tomato, cabbage, lettuce, and other

plants may be raised from seed in a hotbed. The schoolroom is made more attractive by a window garden, in which grow geraniums and other plants. Ferns flourish in a northern exposure. The Chinese sacred lily will grow and blossom if the bulb be put in a pan of

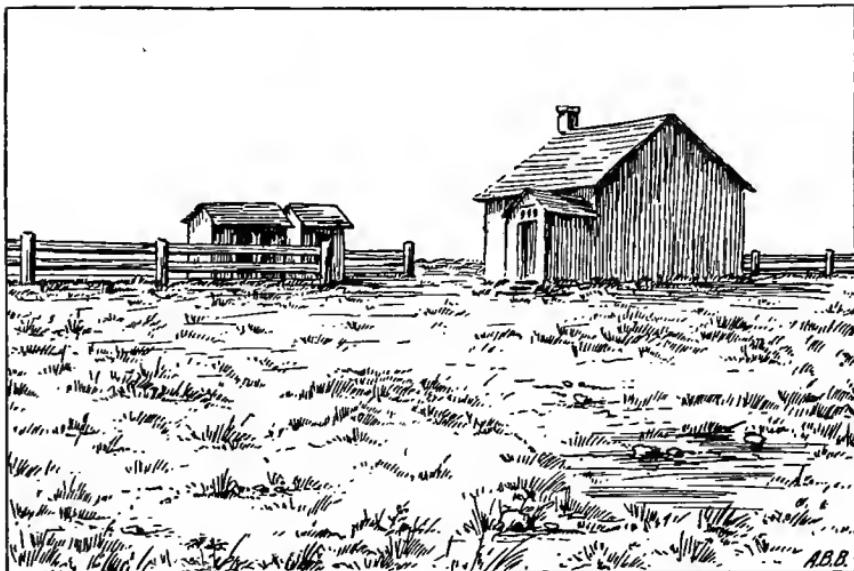


A CITY CHILD'S WINDOW GARDEN—
THREE BROKEN EGGSHells

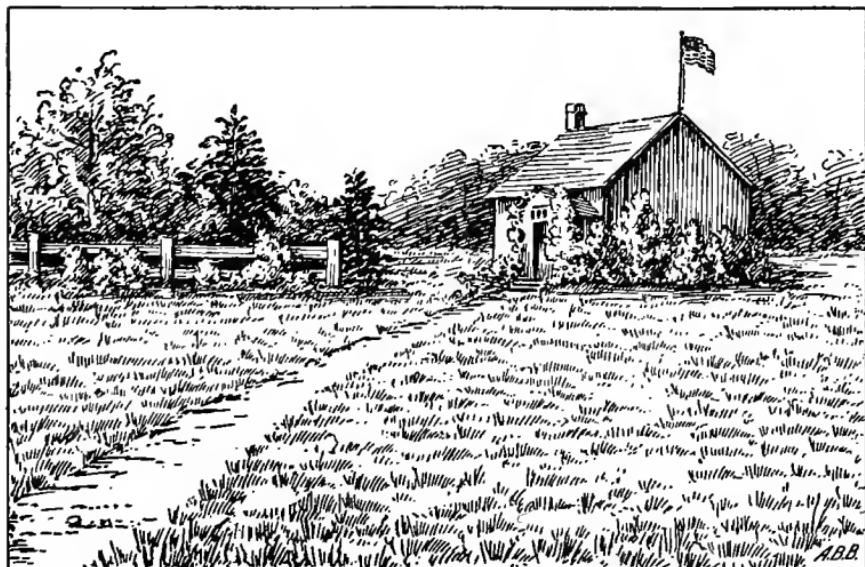
water with sand and pebbles at the bottom.



FLAT, OR TRAY, FOR STARTING PLANTS FOR
TRANSPLANTING



A SCHOOLHOUSE OF A NOT UNCOMMON TYPE



THE SAME, IMPROVED BY THE PLANTING OF TREES AND VINES

School Grounds.—Young gardeners may do much to make school grounds attractive. Of course, a playground is needed, and it should not be encumbered with shrubs and flower beds. But the schoolhouse may be shaded with trees, bare corners may be beautified with shrubs and flowers, and outbuildings may be screened with vines. Flowers should be planted in beds and borders, and trees and shrubs should be set in groups, with the larger ones at the back. Among desirable trees, shrubs, and vines are the elm, linden, oak, and maple, dogwood, lilac, and snowball, ivy, Virginia creeper, and morning-glory.

Landscape Gardening.—Study attractive and unattractive grounds, and try to understand the reasons for the difference in appearance. “Two trees and six shrubs, a scrap of lawn, and a dozen plants may form either a beautiful little picture or a huddled disarray” of forms and colors. Landscape gardening is an art that makes pictures with grass and trees and other natural objects instead of with pencil and brush. If we wish to secure good results, we must have a plan, the simpler the better, and a picture in our minds of the result we wish to obtain. We must be sure to plant the right things in the right place and in the right way.

APPENDIX

MIXING FERTILIZERS

ALL the 'machinery' necessary is a tight floor or a smooth hard place on the ground, scales, a shovel or hoe, an iron rake, and a sand screen. Lumpy materials should be pulverized and run through the screen before they are added to fine ones. The most bulky material should be spread on the floor in a layer about six inches deep, then the next material should be spread on top of this, and so on till all are added in layers to the pile. The pile should then be shoveled and raked over from top to bottom so as to mix the materials well. This process should be repeated three or four times and then the mixture passed through the screen. It is then ready for use.

Acid phosphate is the cheapest and one of the best sources of phosphoric acid. Various grades are sold, ranging from 7 to 18 per cent available phosphoric acid. The higher grades are the more economical.

Nitrate of soda is $15\frac{1}{2}$ to 16 per cent nitrogen; sulphate of ammonia 19 to $20\frac{1}{2}$ per cent; dried blood 12 to 14 per cent; tankage 5 to $12\frac{1}{2}$ per cent; and cotton-seed meal $6\frac{1}{2}$ to $7\frac{1}{2}$ per cent.

Nitrate substitutes may be made on the following basis: for one pound of nitrate of soda use one pound of high grade dried blood, or two pounds of cotton-seed meal.

Muriate of potash, which is 50 per cent potash, is the cheapest form of potash for crops such as corn, peas, and cotton; but the salt in the muriate or in kainite, which is 12 or $12\frac{1}{2}$ per cent potash, injures the quality of some crops, such as tobacco and potatoes. For these it is better to use sulphate of potash, 18 to 52 per cent potash, or hard-wood ashes, 2 to 8 per cent potash. Ashes should never be mixed with acid phosphate unless both are perfectly dry, and neither ashes nor lime should be mixed with stable manure.

Potash substitutes may be made on the following basis: for each one pound of muriate of potash use one pound of high-grade sulphate of potash or four pounds of kainite or ten pounds of dry unleached hard-wood ashes.

Fertilizer formulas should give the per cent of available phosphoric acid, nitrogen, and potash. Often instead of the per cent of nitrogen there is given the per cent of ammonia which is $\frac{1}{4}$ nitrogen, and the per cent of sulphate of potash which is about 50 per cent potash. The fertilizer which claims 8 per cent sulphate of potash is therefore equal to one which claims 4 per cent potash, and one which claims 4.5 per cent ammonia is equal to one claiming 3.8 nitrogen.

SOME FERTILIZER FORMULAS

I. FOR CORN

Acid phosphate, 14%	950 lb.
Cotton-seed meal	1000 lb.
Muriate of potash	50 lb.

Apply so as to get 100 to 200 lb. of acid phosphate to the acre.

II. FOR COTTON

Acid phosphate, 14%	1250 lb.
Dried blood, 13% nitrogen	600 lb.
Muriate of potash	150 lb.

Apply so as to get 200 to 400 lb. of acid phosphate to the acre.

III. FOR TOBACCO

Acid phosphate, 14%	1065 lb.
High-grade dried blood, 13% nitrogen	500 lb.
Nitrate of soda	125 lb.
Sulphate of potash, 50% potash	310 lb.

IV. FOR LEGUMES

When seed is inoculated so that the legumes can collect their own nitrogen.

Acid phosphate, 14%	1800 lb.
Muriate of potash	200 lb.

Apply so as to get 200 to 300 lb. of acid phosphate to the acre. On poor land legumes do better when a small amount of nitrogen is supplied by the fertilizer.

FORMULAS FOR SPRAYING PREPARATIONS

FUNGICIDES

I. COPPER SULPHATE

For wintering spores

Copper sulphate	1 lb.
Water	15 gal.

For peaches and nectarines use 25 gallons of water. Use on tree trunks and branches before buds open.

II. BORDEAUX MIXTURE

For blight, mold, rot, scab, and all other fungous diseases of plants in foliage.

Copper sulphate	6 lb.
Unslack'd lime	4 lb.
Water	50 gal.

For peaches, plums, and cherries double the quantity of water. Dissolve the copper sulphate in hot water in an earthen or wooden vessel, and then dilute it to 25 gallons. Slack the lime in a wooden vessel with boiling water, slowly and carefully so as to form a smooth paste. Dilute it to 25 gallons. When cool, mix with the copper-sulphate solution, stirring thoroughly.

III. AMMONIACAL COPPER CARBONATE

For fungous diseases of ripening fruit

Copper carbonate	5 oz.
Ammonia, 26%	3 pt.
Water	50 gal.

This mixture does not stain nor roughen ripening fruit. Make the copper carbonate into a paste with $1\frac{1}{2}$ pints of water. Dilute the ammonia with $1\frac{1}{2}$ gallons of water and dissolve the paste in it. This stock solution can be kept in glass-stoppered bottles and diluted as wanted, by adding 6 gallons of water to each quart of the solution.

IV. FORMALIN

For smut and scab

Formalin	1 pt.
Water for scab	30 gal.
Water for smut	50 gal.

Mix and moisten thoroughly the grain and potatoes to be used for seed, just before planting. Put the potatoes in a bag and soak for two hours in the preparation. Grain should be soaked twenty minutes and then spread so as to dry without heating.

INSECTICIDES

I. PARIS GREEN

For chewing insects on plants, such as codling-moth larvae, potato beetles, etc.

Paris green	1 lb.
Water	150 to 300 gal.

For use on trees in foliage, especially fruit trees, add 1 lb. of unslack'd lime. Paris green is a poison, and should be used with care. It should be mixed to a thin paste with water, diluted to the required amount, and kept well stirred.

A dry preparation is made by mixing one pound of Paris green with from 20 to 50 lb. of flour gypsum, or air-slacked lime. This should be mixed thoroughly and dusted on plants, preferably while they are wet with rain or dew.

II. KEROSENE EMULSION

For sucking insects, such as aphides, or plant lice.

Hard soap	.	.	.	.	.	.	.	.	.	.	.	½ lb.
Boiling water	.	.	.	.	.	.	.	.	.	.	.	1 gal.
Kerosene	.	.	.	.	.	.	.	.	.	.	.	2 gal.

Dissolve the soap in the boiling water. Add the kerosene and churn with a pump from five to ten minutes. Dilute with from 8 to 50 gallons of water, using the strong solution for scale insects.

III. BISULPHIDE OF CARBON

For grain moths, weevils, and all insects affecting stored food and seed.

One teaspoonful to each cubic foot of space.

Pour into a saucer or shallow pan and set on the top of the grain in a tightly closed bin. The bisulphide is very inflammable, and should be kept from light and fire.

IV. COBALT SIRUP

For poisoning tobacco flies and other flies and moths.

Cobalt	.	.	.	.	.	.	.	.	.	.	.	1 oz.
Molasses	.	.	.	.	.	.	.	.	.	.	.	¼ pt.
Water	.	.	.	.	.	.	.	.	.	.	.	1 pt.

Insert in the blossom of the Jamestown weed by means of a quill.

FUNGICIDES AND INSECTICIDES

I. BORDEAUX PARIS GREEN

Bordeaux mixture	.	.	.	.	.	.	.	.	.	.	.	50 gal.
Paris green	.	.	.	.	.	.	.	.	.	.	.	4 oz.

II. LIME, SALT, SULPHUR WASH

For winter application for San Jose scale

Lime	.	.	.	.	.	.	.	.	.	.	.	15 lb.
Sulphur	.	.	.	.	.	.	.	.	.	.	.	15 lb.
Salt	.	.	.	.	.	.	.	.	.	.	.	5 lb.
Water	.	.	.	.	.	.	.	.	.	.	.	50 gal.

Heat 4 or 5 gallons of water in a twenty-gallon iron kettle. Put in 15 lb. of lime; while it is slackening, add 15 lb. of sulphur and add boiling water to make a thick paste. Add more water so as to make about 10 or 15 gallons. Keep the mixture well stirred, and boil thirty or forty minutes. Strain, add the salt, and dilute to 50 gallons.

AVERAGE DIGESTIBLE NUTRIENTS IN AMERICAN FEEDING STUFFS

FEEDING STUFFS	DIGESTIBLE NUTRIENTS IN 100 POUNDS		
	Protein	Carbohydrates	Fat
Alfalfa hay	11.0	39.6	1.2
Corn stover, field cured	1.7	32.4	0.7
Cowpea hay	10.8	38.6	1.1
Red clover hay	6.8	35.8	1.7
Timothy hay	2.8	43.4	1.4
Cow's milk	3.6	4.9	3.7
Skimmed milk	3.1	4.7	0.8
Buttermilk	3.9	4.0	
Barley	8.7	65.6	1.6
Corn	7.9	66.7	4.3
Kafir corn	7.8	57.1	2.7
Rice	4.8	72.2	0.3
Rye	9.9	67.6	1.1
Wheat	10.2	69.2	1.7
Cotton seed	12.5	30.0	17.3
Cotton seed meal	37.2	16.9	12.2
Cotton seed hulls	0.3	33.1	1.7
Cowpeas	18.3	54.2	1.1

FEEDING STANDARDS

Pounds, per day, per 1000 lb. live weight.

KIND OF ANIMAL	Protein	Carbo-hydrates	Fats	Nutritive Ratio
Horse, at light work	1.5	9.5	0.40	I: 7.0
Horse, at hard work	2.8	13.4	0.80	I: 5.5
Oxen, at rest	0.7	8.0	0.15	I: 12.0
Oxen, at hard work	2.4	13.2	0.50	I: 6.0
Fattening oxen	3.0	14.8	0.70	I: 5.5
Milch cows	2.5	12.5	0.40	I: 5.4
Wool-producing sheep	1.2	10.3	0.20	I: 9.0
Fattening sheep	3.5	14.4	0.60	I: 4.5
Fattening swine	4.0	24.0	.	I: 6.0
GROWING CATTLE				
Age, months	Average weight, per head			
2-3	150 lb.	4.0	13.8	2.0
3-6	300 lb.	3.2	13.5	1.0
6-12	500 lb.	2.5	13.5	0.6
12-18	700 lb.	2.0	13.0	0.4
18-24	850 lb.	1.6	12.0	0.3

LIST OF FARMERS' BULLETINS

FOR SUPPLEMENTARY READING

The following Farmers' Bulletins, issued by the Department of Agriculture, contain practical, scientific information on the subjects treated in this book. Copies are sent free on application to a Senator or Representative in Congress or to the Secretary of Agriculture.

Write to your State Agricultural Experiment Station also for copies of its bulletins. These bulletins furnish excellent material for supplementary reading and study along desired lines. By their use work can be adapted to different grades and to special local conditions.

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88. Alkali Lands.

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111. Farmers' Interest in Good Seed.
 260. Seed of Red Clover and Its Impurities.
 157. The Propagation of Plants.

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 257. Soil Fertility.
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 217. Essential Steps in securing an Early Crop of Cotton.
 274. Flax Culture.
 60. Methods of Curing Tobacco.
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 83. Tobacco Soils.
 52. The Sugar Beet.
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 208. Varieties of Fruits recommended for Planting.
 113. The Apple and How to grow It.

- 255. The Home Vegetable Garden.
- 35. Potato Culture.
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- 127. Important Insecticides.
- 155. How Insects affect Health in Rural Districts.
- 47. Insects Affecting the Cotton Plant.
- 70. Insect Enemies of the Grape.
- 99. Insect Enemies of Shade Trees.
- 120. Insects Affecting Tobacco.
- 132. Insect Enemies of Growing Wheat.
- 216. The Control of the Boll Weevil.
- 223. Miscellaneous Cotton Insects in Texas.
- 247. The Control of the Codling Moth and Apple Scab.
- 275. The Gypsy Moth and How to control It.

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- 32. Silos and Silage.

- 42. Facts about Milk.
- 55. The Dairy Herd.
- 63. Care of Milk on the Farm.
- 71. Essentials in Beef Production.
- 72. Cattle Ranges of the Southwest.
- 106. Breeds of Dairy Cattle.
- 143. The Conformation of Beef and Dairy Cattle.
- 151. Dairying in the South.
- 241. Butter Making on the Farm.
- 258. Texas or 'Tick Fever and its Prevention.
- 261. The Cattle Tick.
- 170. Principles of Horse Feeding.
- 179. Horseshoeing.
- 49. Sheep Feeding.
- 96. Raising Sheep for Mutton.
- 137. The Angora Goat.
- 24. Hog Cholera and Swine Plague.
- 100. Hog Raising in the South.
- 41. Fowls: Care and Feeding.
- 51. Standard Varieties of Chickens.
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- 228. Forest Planting and Farm Management.
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STATE AGRICULTURAL EXPERIMENT STATIONS

Alabama—College Station: *Auburn.*
 Canebrake Station: *Uniontown.*
 Tuskegee Station: *Tuskegee.*
 Arizona—*Tucson.*
 Arkansas—*Fayetteville.*
 California—*Berkeley.*
 Colorado—*Fort Collins.*
 Connecticut—State Station: *New Haven.*
 Storrs Station: *Storrs.*
 Delaware—*Newark.*
 Florida—*Lake City.*
 Georgia—*Experiment.*
 Idaho—*Moscow.*
 Illinois—*Urbana.*
 Indiana—*Lafayette.*
 Iowa—*Ames.*
 Kansas—*Manhattan.*
 Kentucky—*Lexington.*
 Louisiana—Sugar Station: *New Orleans.*
 State Station: *Baton Rouge.*
 North Station: *Calhoun.*
 Maine—*Orono.*
 Maryland—*College Park.*
 Massachusetts—*Amherst.*
 Michigan—*Agricultural College.*
 Minnesota—*St. Anthony Park, St. Paul.*
 Mississippi—*Agricultural College.*

Missouri—College Station: *Columbia.*
 Fruit Station: *Mountain Grove.*
 Montana—*Bozeman.*
 Nebraska—*Lincoln.*
 Nevada—*Reno.*
 New Hampshire—*Durham.*
 New Jersey—State Station: *New Brunswick.*
 College Station: *New Brunswick.*
 New Mexico—*Mesilla Park.*
 New York—State Station: *Geneva.*
 Cornell Station: *Ithaca.*
 North Carolina—*Raleigh.*
 North Dakota—*Agricultural College.*
 Ohio—*Wooster.*
 Oklahoma—*Stillwater.*
 Oregon—*Corvallis.*
 Pennsylvania—*State College.*
 Rhode Island—*Kingston.*
 South Carolina—*Clemson College.*
 South Dakota—*Brookings.*
 Tennessee—*Knoxville.*
 Texas—*College Station.*
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 Vermont—*Burlington.*
 Virginia—*Blacksburg.*
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 West Virginia—*Morgantown.*
 Wisconsin—*Madison.*
 Wyoming—*Laramie.*

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[A word-list with definitions is not considered necessary for this book. The pronunciation and definition of unusual and technical words are given in the text when first used; when it is desired to refer to any of these, they may be found by means of the index.]

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